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GEOGRAPHY
FOR
SENIOR CLASSES

BY

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PREFACE

THIS book, a *Geography for Senior Classes*, is the third of a series, the two earlier books being *First Lessons in Geography* and a *Geography for Junior Classes.* It is intended for use in the higher forms of Secondary Schools, and it provides a course of study up to the standard of the General School Examination.

Part I. deals with World Geography, and includes lessons on the Earth as a Planet, Land Forms, Wind Belts, and Ocean Currents.

Parts II.-V. deals with the Continents, and the descriptions are arranged on a regional basis.

Great care has been taken to illustrate the various lessons with numerous maps and pictures. At the end of each lesson a few exercises are set for purposes of revision, and at the end of the book a large number of questions selected from recent examination papers are given for those who are studying for the various school examinations.

In preparing the text, reference has been made to the *Statesmen's Year Book*, the *International Geography*, many Government publications, and to the works of Geikie, Gregory, Huxley, Lockyer, Mill, Balfour Stewart, and many others. The Authors are indebted to the writers of these books for much valuable information.

GEOGRAPHY FOR SENIOR CLASSES

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GEOGRAPHY FOR SENIOR CLASSES

PART I.—WORLD GEOGRAPHY.

1. THE EARTH.

In very early times all men believed that the earth was a vast flat plain with hills and mountains rising on it here and there, and that it was encircled by the ocean. They thought that the sky was a great dome or vault of blue, resting on the earth, and that the stars were fixed in the dome, which went round and round. The sun, the moon, and the planets seemed to them to move across the sky-dome, while the great earth-plane stood still below them.

But now we know that the earth is a great spinning ball or globe that is for ever revolving round the sun. The surface of a globe is curved. That the surface of the earth is a curve may be shown in many ways.

Stand three rods of the same length, say 7 feet, upright on corks floating on a lake, in a straight line, so that the first rod I may be two miles apart from the third rod III, and the second rod II exactly in the middle. Fix a white ball on the head of each rod. Then look along the three balls through a telescope at one end of the line. If the surface of the water were on the same level, the three balls would be on the same level, like this:

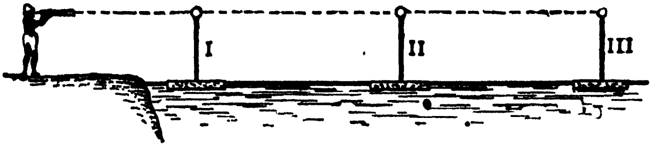

Fig. 1.

But it is not so. You will find that ball II is about 8 inches above the level of the other two balls, like this:

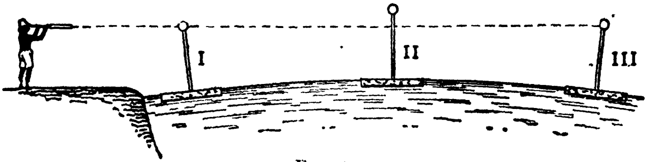

FIG. 2.

This shows that the surface of the water rises up in the middle. It is a curve. Everywhere, on the water or on a flat piece of land, there is an upward curve of 8 inches between any two points two miles apart.

The edge of the shadow of the earth is a curve, as any one may see for himself in an eclipse of the moon, when the shadow of the earth is cast upon the moon.

If a ship sail round the earth, keeping in the same direction all the time, it will at length come back to the place from which it started, just as an ant or a fly, crawling over an orange, comes back to its starting-point. This the ship could not do unless it were sailing in a circle round a globe.

When we stand on the shore of the sea and watch a ship moving away from us, we can see the sails or the funnels and the masts some time after the hull has sunk out of sight. If the surface of the sea were flat, we should see the hull longest, as it is the largest and most bulky part of the vessel.

If the earth were flat, the rising sun would be visible everywhere at the same time. But instead of this, the sun rises later and later as we go westwards, and earlier and earlier as we go eastwards. And the same stars would be visible everywhere every night if the earth were flat. But as we travel northwards or southwards, many stars sink out of sight, being hidden from view by the upward curve of the earth's surface.

The circle that a man sees around him on the land or on the sea, where the sky seems to meet the surface of the land or water, is called the horizon. Everywhere, if the eye be 5 feet above the sea-level, the horizon is about 2¾ miles away. From 8 feet above the level of the sea, the horizon is 3 miles off. If a man climbs a height, he can see farther and farther, and the horizon gets wider and wider. At the height of 5600 feet a man can see 80 miles all round him. At the height of 24,000 feet the horizon is 160 miles off. The higher one goes, the wider is the horizon, and everywhere it is a perfect circle round the point of observation in the centre. This could only be the case on the surface of a globe.

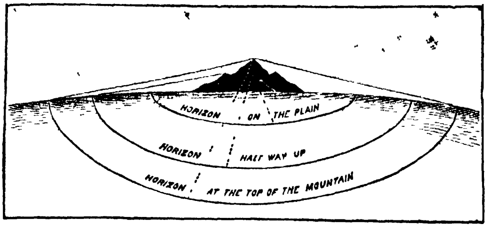

FIG.

The sun, the moon, and the planets are all globes, as we can see for ourselves. The earth is a planet, and it is not likely that its shape would be different from that of all other heavenly bodies.

For these reasons we know that the surface of the earth is everywhere curved, that it is therefore a globe or sphere. Like the sun, moon, and stars, it rests on nothing, and hangs from nothing. It floats freely in space.

EXERCISES.

1. What ideas did men have, in the earliest ages, of the shape of the earth and of its relation to the sun, moon, and stars? How are we reminded of these early notions by words in use in modern speech?
2. How far and by what proofs do we know the shape of the earth?
3. If the earth is moving, why do we not see it move?

2. ROTATION OF THE EARTH: ITS SHAPE.

DAY AND NIGHT.

THE great earth-ball is for ever spinning round and round. This movement is called *rotation*. The earth rotates round an imaginary line through its centre, and this line is called its *Axis.* The axis does not move, the earth moves round it.

The two points at the ends of the axis are its *Poles.* If a line be drawn right round the surface of the earth, midway between the poles, it will divide it into two equal parts. This line is called the *Equator.* Each half is a hemi-sphere or half-sphere.

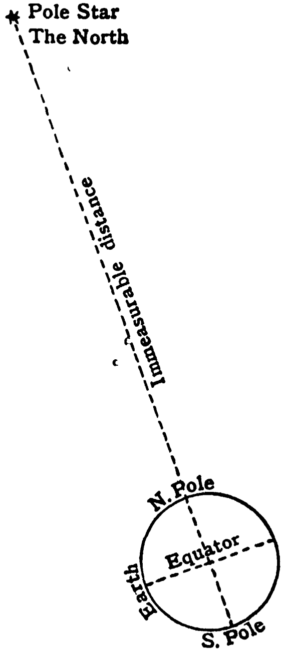

FIG. 4.

As the earth rotates round its axis, the axis itself always points towards a star in the heavens, a star so far away that we cannot measure its distance from the earth. It is called the Pole Star or North Star. The pole of the earth's axis, that points towards it, and is the nearer to it, is called the *North Pole.* The other end of the axis, which points away from it, is the *South Pole.*

It takes just 24 hours for any point on the earth to go right round—to rotate once. Opposite to the rotating earth there is the great glowing orb of the sun. It is about 93 millions of miles away, but its rays bathe the earth in light and heat. As the earth spins round, every point on its surface comes into the sunlight in the morning, moves round in the sunlight all day, and at night slips away into the dark. One half of the earth is always in the sunlight, and here it is day. The other half is at the same time in the dark, and here it is night.

Thus we see how the rotation of the earth, on its axis, opposite the sun, causes day and night.

The earth rotates from west to east. As each point in turn spins eastwards into the sunlight, the sun is said to rise there, *i.e.* in the east, and as it spins out of the light westwards, the sun is said to set there, *i.e.* in the west.

That the earth rotates from west to east has been proved in many ways. If a stone be dropped into a very deep, narrow well, it does not fall into the water at the bottom, but strikes against the eastern side of the well. In the same way, a stone dropped from the top of the east face of a high tower falls to the ground a little to the east of the point just underneath. This shows that the earth is spinning from west to east.

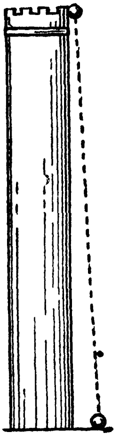

FIG. 5.

The Exact Shape of the Earth.—The earth is a globe or sphere, but not a perfect sphere. In a true sphere, as in a circle, every radius, every line from the centre to the circumference, is exactly equal. But it has been found that the earth-globe is slightly flattened at the poles, and bulges out slightly at the equator.

The circumference of the earth is 24,900 miles, or in round numbers 25,000 miles at the equator.

The diameter through the centre at the equator is 7926 miles, but the diameter from the North to the South Pole, through the centre, is 26 miles shorter, being about 7900 miles. A body very like a sphere is called a *spheroid*, and a spheroid, flattened slightly at the poles, is said to be *oblate*. Thus the earth may be called an *oblate spheroid.*

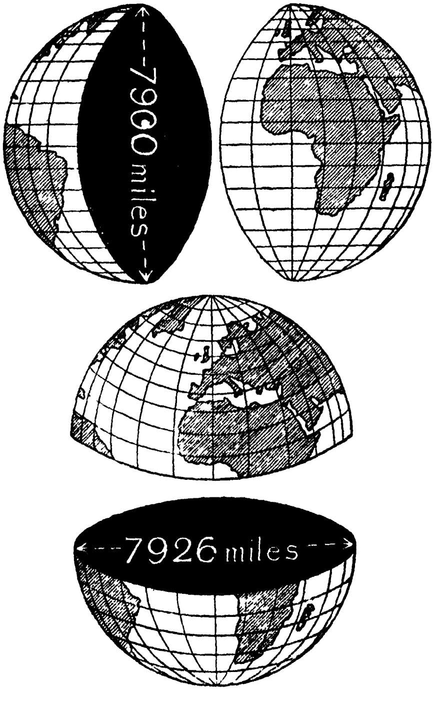

FIG. 6.

We know this by actual measurement. A globe, made of any material, solid or liquid or gas, will flatten at the poles and bulge out in the middle if it be made to spin rapidly round on its axis. Also we can see that the other planets and the moon, which, like the earth, are all spinning globes, have this shape—they are all oblate spheroids.

Points of the Compass.—The two points, North and South, on the earth's surface, are fixed by the two ends of its axis, *i.e.* by the North Pole and the South Pole. And two other points, East and West, are fixed for us by the rising and the setting sun. These four are called the four cardinal or chief points. They are also known as points of the compass. The word compass means *circle.* We may divide into two the spaces between each pair of these points, and thus get four more points as shown in Fig. 7. Midway between north and east there is the north-east, marked N.E. Between north and west lies the north-west or N.W. Between south and east there is the south-east, marked S.E. And between south and west there is the south-west or S.W.

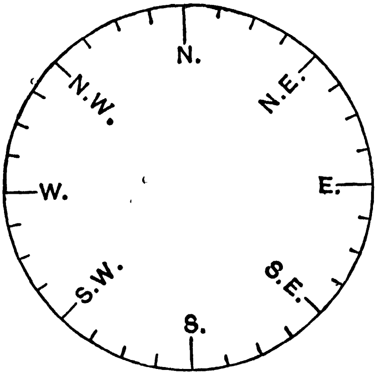

FIG. 7.

There are still smaller subdivisions made on a mariner's compass, some of which are marked, though not named, in Figs. 7 and 8.

On a bright clear night we can tell where the north lies by the Pole Star. But often we cannot see the stars because of clouds or fogs in the sky. Is there no other way of finding the north and the south? There is.

There are stones known as *magnets,* so called because they are found chiefly in Magnesia in Asia Minor. These stones have a wonderful force called magnetism. They *attract* or pull iron towards them. If a magnet be held close to small pieces of iron, they jump to the magnet and cling to it. If the magnet be held up, they hang from it and do not drop off. And if a long magnet be suspended by a string, one end will always point to the north and the other end to the south. For this reason these stones are also called *lode-stones*, *i e.* leading-stones, because they lead to or point out the north. If a piece of iron or steel be gently rubbed or stroked with a lode-stone it becomes a magnet, and will also attract iron or steel and point to the north. It is said to be magnetised. If a steel needle which has been magnetised be placed on an upright pin, so that it can move round freely, one end will always point to the north and the other to the south.

In Fig. 8 we see a compass. It is a little box with a glass top to it. Inside there is a circle, on which are marked the eight points of the compass which have been mentioned. There is the magnet needle on a pin, pointing to the north.

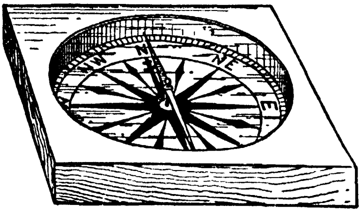

FIG. 8.

Before the compass was invented, sailors were afraid to sail out on the wide ocean, for if they could not see the sun on a cloudy day or the stars on a foggy night, they could not find their way. Now every ship carries a "mariner's compass," and with its aid the mariners or sailors can find their way anywhere over the trackless ocean.

EXERCISES.

1. Say, in your own words, what is meant by : rotation, sphere, diameter, axis, poles.

2. What is the equator ? What is its length ?

3. What is the difference in length between the polar and the equatorial diameter of the earth ?

4. What really happens when the sun seems to us to set and rise ?

5. Explain fully the meaning of the term "oblate spheroid."

6. What is a magnet ? Why is it so called ? Describe the mariner' compass.

3. LATITUDE AND LONGITUDE.

THE surface of the earth being curved, distance over it is measured by *circular measure.* The circumference of every circle, great or small, may be divided into 360 equal parts called degrees. One degree is written 1°, two degrees are written 2°, and so on. A degree is divided (like an hour) into 60 parts called minutes, marked ′, and every minute is divided into 60 parts called seconds and marked ″. Degrees, minutes, and seconds in circular measure do not show time, but distance or length. The length in miles of a degree depends on the size of the circle of which it is a 360th part.

A half circle, or semicircle, contains 180°, and a quarter circle, or quadrant, contains 90°.

The circumference of the earth is a circle. Any line which goes right round the earth measures about 25,000 miles. One degree of a line like this measures 25,000 ÷ 360, *i.e.* about 69½ miles. The distance from the equator over the surface of the globe to either pole is a quarter circle or 90°, and the distance from pole to pole is a semicircle or 180°.

Great Circles.—A circle which divides the globe into two equal parts (*i.e.* into hemispheres) is called a great circle; therefore all circles passing through the poles are great circles. Only one "great circle" can be drawn round the globe from *east to west.* This is the equator. It measures about 25,000 miles, and the length of 1°, measured east and west along the equator, is about 69½ miles.

Any number of small circles may also be drawn round the globe from east to west parallel with the equator; they divide the globe into unequal parts. The North Pole is an imaginary point. If we draw a circle on the face of the globe just below the North Pole, the pole being the centre, it will be a very small circle. If it be drawn, say, half a mile from the pole, it will measure 3 miles round, so that each degree will be about 45 feet in length. A point on this line will take 24 hours to rotate 3 miles. We may go on drawing circles one below another. Each of them will be larger than the circle above it, and each may be divided into 360°. The length of a degree will be longer and longer as the circles get larger and larger. At a point 20° from the North Pole, a degree of one of these circles would measure 23½ miles; at 40° it would measure 44½ miles; at 60° it would measure 34¾ miles, and at the equator itself, which is 90° from the pole, it would measure 69½ miles (nearly). As the earth spins round, every point upon it is spinning round with it. Near the pole, as we have seen, a point is carried round at the rate of 3 miles in 24 hours, *i.e.* 1 mile in 8 hours. This is its *velocity*, *i.e.* the rate at which it moves. It moves very slowly. But at the equator every point on the surface is carried round 25,000 miles in the same time, *i.e.* at the rate of more than 1000 miles an hour. The velocity is far greater. A boy in Bombay is travelling round with the earth at the rate of about 16 miles every minute, while a boy in London is doing only 11 miles in the same time.

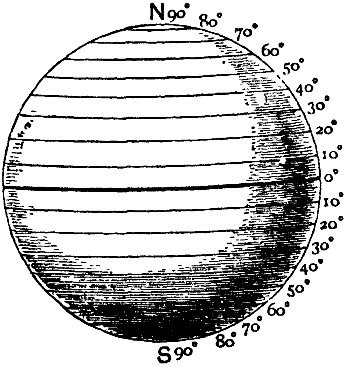

FIG. 9.

In the same way, we may draw circles, one above another, from the South Pole, which is a point, as the centre. These circles will get larger and larger till we reach the equator, which is, as we have seen, the largest circle that can be drawn from east to west round the earth. As in the northern hemisphere, the velocity of any point on the surface of the spinning globe is very low near the South Pole and greater and greater up to the equator.

This fact, that the velocity of the spinning earth is so much greater at the equator than at the poles, has a great effect, as we shall see, on the winds and rain, and so on climate.

As all these circles north and south of the equator are parallel to one another and to the equator, they are called parallels.

The lines are therefore termed *Parallels of Latitude.* The angular distance of a place from the equator is called its latitude.

Of course every place on any one of these lines is at the same distance from the equator as the line itself, for it is a point on the line. The latitude of a place is the latitude of a parallel on which it stands. The distance from the equator of every parallel is marked on the margin of a map. Any number of parallels may be drawn on a map at any distance from one another. If a map be large, a good many may be drawn; on a small map only a few can be drawn. In Fig. 9 a parallel is drawn for every 10°, and on the margin are the figures 10°, 20°, 30°, and so on. Places on lines with these low figures are said to be in "low latitudes," *i.e.* not very far from the equator. The figures may go up to near 90°, *i.e.* North and South Poles, and this is the highest latitude any place can have. Places on lines marked with the higher figures are said to be in "high latitudes." The equator itself is marked 0° or zero, for if a place be *on* the equator it cannot be at any distance from it. In other words it has no latitude.

In the physical map of India, Map 6, the parallels of latitude are marked at every 4°. In the map of the British Isles, which is on a larger scale, they are marked at every 2°.

Day and night are caused by the rotation of the earth on its axis, opposite to the sun. Twice in the year, as we shall see, the days and nights are equal in length all over the world, the day lasting 12 hours and the night 12 hours. Fig. 10 shows the earth as it is lit up by the sun at these times, called *equinoxes*, or equal nights.

In this figure, the earth is rotating from west to east as shown by the direction of the arrows. The North Pole is opposite to you. You are looking down upon it. The South Pole you cannot see. It is on the other side of the globe. The equator is the line all round the edge of the circle, opposite to the rays of the sun. The east is the point marked "sunrise," and the west is the point marked "sunset."

You see how the solar rays light up one half of the earth at a time. The line dividing the light from the darkness we may call the sunrise and sunset line. It is sunrise at the same moment for all the places along this line, from the North Pole to the South Pole. As the earth rotates, this line of places spins eastwards, another line of places taking its position on the sunrise line. On it goes, till in six hours it comes to the point marked 12 noon. Here it is called the meridian or mid-day line, the Latin word for mid-day being *meridies.* It is noon at the same time for all the places on this line, the sun being right overhead. As the globe spins on, each of the other lines, with the places on it, comes opposite to the sun, and becomes, in its turn, the meridian. All lines are therefore called meridians, which are drawn from the North Pole to the South Pole. They are all "great circles" going right round the earth. They meet at the poles and then get wider and wider apart, being widest apart at the equator. Each of them measures about 25,000 miles, and the length of a degree on any one of them is about 69½ miles.

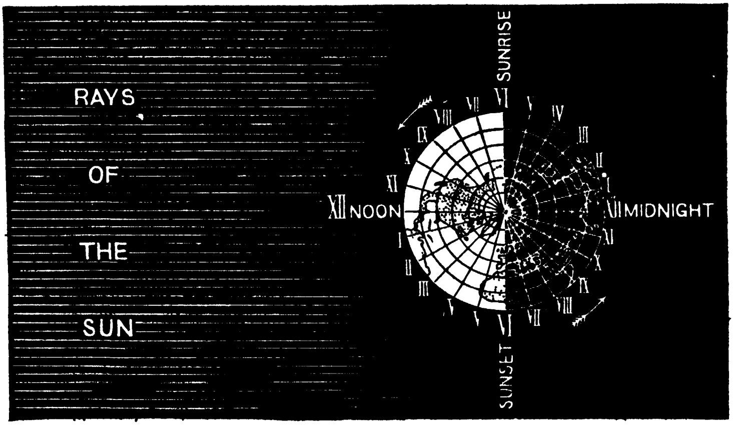

FIG. 10.

Longitude.—The latitude alone of a place does not show its exact position on the face of the earth. If, for example, we were told that the latitude of a place was 10° N., we might, no doubt, find it by looking along that line across a map till we came to it. To save us this trouble, and to show us exactly on what point of a parallel a place is, we make use of the meridians. The angular distance of a place east or west of a fixed meridian is termed its longitude, and the meridians are termed *meridians of longitude.*

All British people take the meridian which passes through Greenwich, a suburb of London, as their prime or first meridian. Here is the great national observatory from which the movements of the sun, the moon, and the stars are watched, and the standard time taken for all the watches and clocks throughout the British Isles. Distance east of the Greenwich meridian up to 180° is east longitude, extending half round the globe. Distance in the other direction, to the west, is west longitude, extending round the other half of the globe. Every place through which any meridian passes is at the same distance, east or west, as the meridian itself is from the prime meridian. Just as the latitude of any place on the equator is zero, so the longitude of every place on the meridian of Greenwich is also zero. It has no longitude.

Just as any number of parallels of latitude may be drawn, so any number of meridians may be drawn on a map, as may be seen by looking at the maps in this book. In Fig. 11 they are marked at intervals of 10°, where they cross the equator. In an ordinary map the figures showing longitude will be found in the margins at the top and bottom of the map.

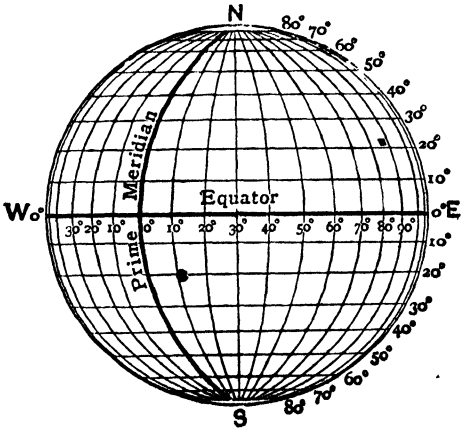

FIG. 11.

The parallels and meridians divide a map into little compartments. These are enough to show us *about* where a place is. For example, Calcutta is in 22° 34′ N. latitude, and in 88° 22′ E. longitude. Look at the top margin of the map of India, Map 6, for the figure 88, and at the margin on either side for the figure 20. Where these lines cross, there is a little compartment, and in it you will find Calcutta.

In Fig. 11 the black dot just above parallel 20° shows about where Calcutta is.

There are no actual lines like the equator and parallels and meridians on the earth itself. They are only drawn on maps and globes.

The earth is our great timekeeper. This may be seen in Fig. 10. If we divide the circle of the equator, *i.e.* 360°, into 24 equal parts, each part will contain 15°. In the figure there are 24 meridians, corresponding to the 24 hours of the day and night, the time it takes for the earth to make a complete rotation. It takes any point on the earth one hour to cross from one of these meridians to another, a distance of 15°. Therefore it moves over 1° in $\frac{1}{15}$ of one hour or 60 minutes, that is to say, it moves over 1° in 4 minutes.

As the earth spins round, each of these 24 meridians comes opposite to the sun in turn, one hour before the meridian behind it. When the sun is on the meridian of Greenwich at mid-day, it is midnight on the meridian of the Fiji Islands (see Map 5). Twelve hours have passed since the sun was on this meridian, which is 180° away. Any two places which are 15° apart differ by one hour in their time. As the earth is spinning eastwards, places to the east see the sun sooner than places to the west behind them at the rate of 4 minutes (of time) to 1° (of longitude). Time is later to the east of any given place, and earlier to the west.

All places on the same meridian have the same time, whatever their latitude may be. When it is noon at Stockholm, it is also noon at Brindisi, both places having very nearly the same longitude, viz. 18° E.

But the time is never the same for places on the same parallel of latitude. New Orleans, Cairo, and Lhasa are all situated on latitude 30° N. When it is noon at Greenwich, the time by the sun at New Orleans (90° W.) will be 6 A.M., (allowing 4 minutes for 1°). At Cairo ($31\frac{1}{2}^{\circ}$ E.) and Lhasa ($90\frac{3}{4}^{\circ}$ E.) the corresponding times will be 2.6 P.M. and 6.3 P.M. respectively.

EXERCISES.

1. What are parallels of latitude and why are they so called?

2. If an aeroplane were to fly right round the earth, keeping a straight line, over how many miles would it have travelled?

3. Into how many degrees is the equator divided and what is the length in miles of each degree?

4. At what rate does a point on the earth's surface move—(*a*) at the equator, (*b*) in London?

5. What are meridians of longitude? Why are they so called? Of what use are they?

6. Point out on the map two towns, one of which has no latitude and the other no longitude.

7. "The earth is our great timekeeper." Explain this fully.

8. When it is noon in London, what is the time in—(*a*) New York, (*b*) Petrograd?

4. THE RISING AND THE SETTING SUN.

ON the 21st of March the sun rises at a point on the horizon which we call due east. That day there is sunlight for just 12 hours and darkness for just 12 hours all over the world, from the North Pole to the South Pole. The day and the night are equal in length, and this is therefore known as the *vernal* (or spring) *equi-nox* (*i.e.* equal night).

The next morning, in the northern hemisphere, the sun rises at a point a little more to the north, and for the next three months it keeps on rising a little more northwards every day till the 21st of June, when it seems to stop. In the northern hemisphere this is summer, and the 21st of June is, in this hemisphere, the longest day in the year. In London, *e.g.*, the sun rises that day at 3.44 A.M. and sets at 8.18 P.M., so that the daylight lasts for $16\frac{1}{2}$ hours. Farther northwards the day gets longer and longer, and at the North Pole there is one long day and no night.

The length of the longest day in the year, *i.e.* the longest period of sunlight in the northern or southern hemisphere, is 12 *hours* at the equator, 12½ *hours* at latitude 10°, about 14 *hours* at latitude 30°, 18½ *hours* at latitude 60°, 65 *days* at latitude 70°, 161 *days* at latitude 80°, and 182 *days* at latitude 90°, *i.e.* at the North or South Pole.

As the sun *stops* rising northwards on the 21st of June, this date is called the *Summer Solstice*, *sol* meaning the sun and *stice* being derived from a Latin word meaning "stand still." The next morning the sun, instead of rising northward as before, seems to *turn* southwards and to rise at a point on the horizon a little more to the south. If one looks across this point on the horizon into the sky beyond, into what is called the star-dome, one sees opposite to it a constellation or group of stars which is called Cancer (or the Crab). The point on the horizon is called the *Tropic of Cancer*, the word *tropic* meaning "turning-point."

On the 22nd of September, three months later, the sun rises again at the point at which it rose on March 21, due east. This is autumn in the northern hemisphere. The day and the night are again exactly equal in length all over the world, and so this is called the *Autumnal Equinox.*

For the next three months the sun rises a little more to the south every day till the 21st of December, when it stops again. This is the shortest day in the year in the northern hemisphere. In London the sun rises at 8.6 A.M. and sets at 3.51 P.M., giving only about eight hours of daylight. The day gets still shorter farther and farther northwards, and at the North Pole there is no day at all, but six months of night.

As it is now winter in the northern hemisphere, this date is called the *Winter Solstice.* The next morning, the sun seems to turn northwards once more, and rises a little more to the north. Opposite the point on the horizon where the sun turned northward, there is, in the sky beyond, the constellation called Capricorn (or the Horned Goat). The point on the horizon is called the *Tropic of Capricorn.*

In this way the sun seems to travel northwards and southwards between the Tropics. It never rises to the north of the Tropic of Cancer nor to the south of the Tropic of Capricorn.

The apparent daily rising of the sun at a more northerly point along the horizon for six months in the year, and its rising at a more southerly point for the next six months, is really due to the revolving earth, which, for six months, turns the northern half of its axis towards the sun as it moves round it, and then turns the southern half of the axis towards the sun for the next six months, the northern half being then turned away from the sun.

Exercises.

1. The 21st of March marks the Vernal Equinox. Explain this.
2. What is the longest day in the year in the British Islands? How long is it?
3. Describe the solstices. Why are they so called?
4. On what point on the earth's surface is the sun invisible for about six months? Explain this.
5. Where, in the world, does the sun never set for about six months?

5. REVOLUTION OF THE EARTH ROUND THE SUN.

The Seasons.

The spinning earth moves onward as it spins. It revolve goes round and round the sun, at an immense distance from it, and while doing so, rotates on its own axis 365¼ times. Each rotation we call a day. We say that there are 365 days in a year. The four ¼ days make up one full day in our reckoning of passing time, so that every fourth year we add one day on to February. That year, we say, has 366 days.

The imaginary line in which the earth moves round the sun is called its *Orbit*. This line is very nearly, but not quite, a circle. It is an *Ellipse*, a curve which is longer one way than the other. If the orbit were a perfect circle, the earth would always keep at the same distance from the sun. But it is known that at one point of its orbit the earth is about 91½ millions of miles from the sun. It is then said to be in Peri-helion,[1] or "near the sun." At another point in its orbit the earth is about $94\frac{1}{2}$ millions of miles from the sun. It is then said to be in Ap-helion,[1] or "away from the sun." Its mean distance is therefore $(94\frac{1}{2}+91\frac{1}{2})\div 2=93$ millions of miles.

The *Plane of the Orbit* is the space bounded by the orbit. In Fig. 12 it is the space within the dotted line. If you can think of a very thin sheet of paper stretching across space and passing through the centre of the earth and the centre of the sun and bounded by the orbit, that would show where the plane of the orbit is. But the thinnest paper has some thickness, while a true mathematical plane has length and breadth but no thickness at all.

As the earth moves round the sun, its axis is not perpendicular to the plane of its orbit. *It is inclined to the plane of the orbit at an angle of* $66\frac{1}{2}°$. *This is the cause of the seasons.*

If the axis of the earth were perpendicular or at right angles to the plane of the orbit, as it always is to the equator, then the equator and the plane would be on one straight line as in Fig. 13. The rays of the sun would light up and heat the same parts of the earth in the same way all through the year. The direct rays of the sun would always fall on the equator. There would be no change of seasons. The sun would always rise at the same point on the horizon, due east, and always set at the same point, due west. The days and nights would be equal in length everywhere.

But the earth does not revolve in this position. Fig. 12 shows the revolving earth at twelve points in its orbit for the twelve months in the year. At the summer solstice, on the 21st of June, the upper half of the axis is inclined directly towards the sun; the North Pole with the circle around it—the Arctic Circle—is in the sunlight. Six months later at the opposite point of the orbit, *i.e.* at the winter solstice, on the 21st of December, the upper half of the axis is inclined away from the sun, the North Pole with the Arctic Circle is in the dark. At two other points in the orbit, midway between the summer

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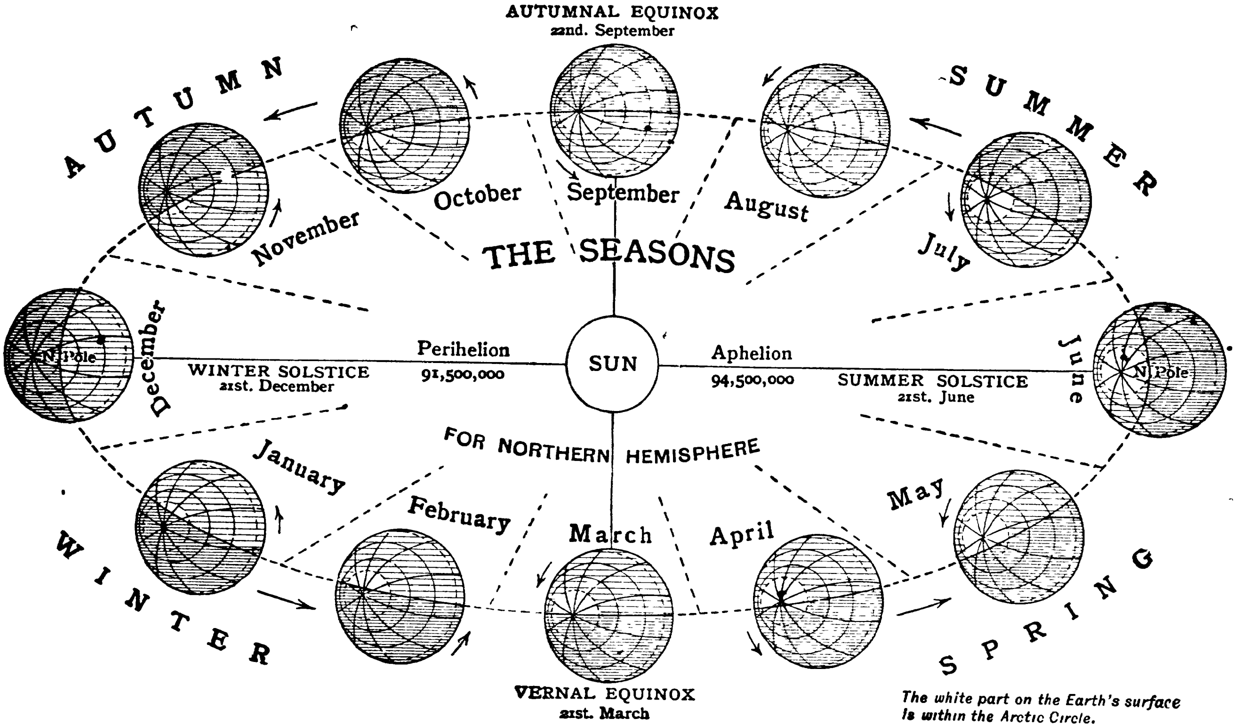
[1] Greek *peri*, near; *apo*, from; *helios*, the sun.



The white part on the Earth's surface is within the Arctic Circle.

FIG. 12.—THE SEASONS.

and the winter solstice, just half of the earth and the Arctic and Antarctic Circles are in the light. These are the two equinoxes.

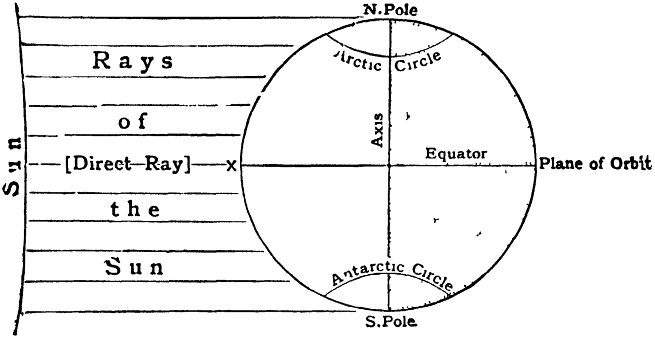


FIG. 13.

Now look at Fig. 14, which shows more clearly and fully how the rays of the sun light up the earth at the summer solstice. As we saw in the last lesson, this is the most northerly point on the horizon at which the sun rises.

The earth is, you see, at that point of its orbit which it reaches on the 21st of June, when the northern half of the axis inclines most towards the sun. This is the longest day in the year in the northern hemisphere. The direct or vertical rays of the sun do not fall on the equator, but on a point 23½° north of the equator. This point is the Tropic of Cancer. We draw an

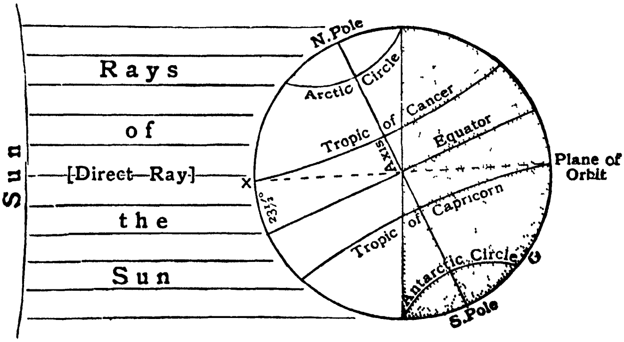


FIG. 14.

imaginary line, a parallel of latitude, round the globe through this point, and the line is known as the Tropic of Cancer. This line of points, and not the equator, is the line of most sun-heat and sun-light at this time of the year in the northern hemisphere; for the equator is now, as you see in the figure, 23½° south of the direct ray. It is summer, the brightest and hottest time of the year. The solar rays light up all that part of the earth lying around the North Pole within the Arctic Circle. But it is now the coldest and darkest time of the year for the southern hemisphere, especially at the South Pole in the Antarctic Circle, which is shaded dark in the figure because the sun's rays do not reach it at all.

Fig. 15 shows the earth at the point of its orbit which it reaches on the 21st of December, the winter solstice. This is

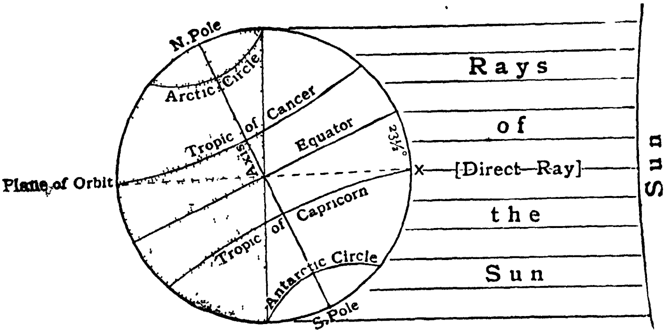


FIG. 15.

the shortest day in the year in the northern hemisphere, when it is midwinter. As we saw in the last lesson, the sun rises, this day, at the most southerly point on the horizon that it ever reaches. The direct or vertical rays of the sun now fall on a point 23½° *south* of the equator. This point is the Tropic of Capricorn. Here again we draw a parallel of latitude round the globe through this point, and the line is known as the Tropic of Capricorn. This line, and not the equator, is the line of most of the sun-light and sun-heat in the southern hemisphere at this time of the year, for the equator is now 23½° north of the direct ray. It is summer in the southern hemisphere. The Antarctic Circle is now in the light, while the Arctic Circle is in the dark. This is because the southern half of the axis now inclines towards the sun while the northern half points away from it.

When it is winter in the northern hemisphere, it is summer in the southern, and while it is winter in the southern hemisphere, it is summer in the northern.

At the two equinoxes (see Fig. 12) the earth is in such a position that the axis is not inclined towards the sun nor away from it, that is to say, the northern and the southern hemispheres have the same inclination towards the sun. The sunlight now covers the whole face of exactly one half of the earth from pole to pole. The equator is now the line of greatest heat and light. The day is exactly equal to the night, *i.e.* twelve hours long, all over the world, and this is why these points are called equinoxes.

Thus the northern limit of the direct rays is the Tropic of Cancer, and the southern limit is the Tropic of Capricorn. These are the two points on the horizon which, as we saw in the last lesson, mark the farthest points, north and south, at which the sun seems to rise. Every point between these two limits gets the direct or vertical rays of the sun sometime or other in the year. No point to the north of the Tropic of Cancer ever gets the direct rays, nor does any point to the south of the Tropic of Capricorn ever get them. *The sun-heat and sun-light line is always changing*, and is always along some parallel of latitude between the two Tropics.

EXERCISES.

1. What makes the day for us? What makes the year?
2. Distinguish between the rotation and the revolution of the earth.
3. Explain what is meant by—(*a*) the orbit of the earth, (*b*) the plane of the orbit.
4. What causes the seasons?
5. How far is the earth from the sun?
6. Explain the terms—(*a*) aphelion, (*b*) perihelion.
7. In what position of the earth, as it revolves, would there be no seasons?
8. What parts of the earth's surface never get the direct rays of the sun?

6. ZONES OF SUN-LIGHT AND SUN-HEAT.

SOME of the solar rays fall directly down on a part of the earth's surface right opposite to them, where the sun is directly overhead at noon. These are called *direct* or *vertical rays*. But the surface of the earth is everywhere a curve, which slopes or slants away in every direction from any point upon it. Rays which fall on a slant or slope are called *oblique* or *slanting rays* to distinguish them from the direct rays. In Fig. 13 the direct ray is falling on the equator. The rays to the north and south are slanting rays. They give less and less light and heat as they fall on the curved surface, sloping away on all sides from the point where the direct ray reaches the surface.

The whole surface of the earth may be divided into broad spaces called *zones*, which mark the degrees of light and heat received from the rays of the sun. Fig. 16 on p. 25 shows these zones.

The circumference of the earth measures, as we have seen, about 25,000 miles. The distance over the surface of the globe from pole to pole is therefore about 12,500 miles, and the distance from the equator to either pole is about 6250, or in round numbers, about 6000 miles.

At the equator, in the middle, there is the *Torrid* or Hot zone, about 3000 miles broad, lying between the Tropic of Cancer and the Tropic of Capricorn. It is clearly marked out by the sun, for the sun always rises at some point on the horizon within these Tropics, and never beyond them. It extends for 23½° north and 23½° south of the equator. The northern half is the North Torrid zone, about 1500 miles broad, and the southern half is the South Torrid, also about 1500 miles broad.

Far to the north and far to the south, around the two poles, lie *Frigid* or cold zones, each about 1500 miles broad. The North Frigid is bounded by the Arctic Circle, which is 23½° south of the North Pole, and the South Frigid is bounded by the Antarctic Circle, 23½° north of the South Pole. These zones are also marked out by the solar rays. For one half of the year, the sun never sets, but may always be seen, low down on the horizon, from the North Pole, where this period is one long day, lasting for six months, without night. At the South Pole, at the same time, the sun never rises at all, and there is one long night (see Fig. 14). For the other half of the year it is night for six months at the North Pole, and day at the South Pole (see Fig. 15).

Between the Frigid zones round the poles in the far north and the far south, and the Torrid zone at the equator in the middle, lie two great belts, one about 3000 miles broad in the northern hemisphere, and another, also about 3000 miles broad, in the southern hemisphere. These are called the *Temperate* zones. Each of them may be divided into a *Warm Temperate* zone, about 1500 miles broad, lying next to the Torrid zone, and a *Cool Temperate* zone, about 1500 miles broad, lying next to the Frigid zone.

The greatest light and heat from the rays of the sun are therefore seen and felt in the Torrid zone. The heat of the rays is not so fierce, nor is there the same blinding blaze of light, in the Warm Temperate zones. Both heat and light grow less to the north and to the south in the Cool Temperate zones, while, in the freezing Frigid zones, the light is feeble and the heat is not enough to melt the ice and the snow which cover the face of the earth around the poles.

The change in temperature is, however, very gradual. There is no sharp or sudden increase of light or heat as we pass across the imaginary line which divides one zone from another. And, as we shall see, the heat at the surface of the earth depends very much on what that surface itself is — whether it is land or sea, a high mountain or a low-lying plain. And we must remember that the line of the greatest heat of the rays along the earth's surface is not always the equator, but that it changes as the earth moves in its orbit round the sun; this heat-line being sometimes north and sometimes south of the equator. These zones of light and heat are therefore not zones of climate.

EXERCISES.

1. What are—(*a*) direct or vertical, (*b*) slanting or oblique solar rays? Why is each so called?
2. Describe fully the various zones of sun-light and sun-heat, into which the earth's surface has been divided. What are the limits and what is the breadth of each?
3. Distinguish between the geographical equator and the heat equator.

7. THE SOLAR SYSTEM.

GRAVITY.

THE earth is a great spinning ball or globe that revolves in space around the central sun. If we look upwards at night into this open space we call the sky, we see the moon and the stars.

The *moon*, like the earth, is a spinning globe which rotates on its axis and revolves round the earth once a month. Like the earth it is a dark body. It has no light of its own, and only looks bright to us because it reflects the light of the sun which shines upon it. It revolves round and round the earth at a distance from it of about 240,000 miles. It is much smaller than the earth, having only one fiftieth of its volume. The sun looks to us as if it were of the same size as the moon. It is, however, enormously larger, and only looks small because of its immense distance. As the moon keeps close to the earth and cannot get away from it and is so much smaller, it seems to belong to the earth, and is called its *satellite* or attendant. The moon and its changes will be more fully described later on in this book.

At night, points of twinkling light, called stars, are seen in the sky. About 6000 stars may be seen in the *whole* sky with the naked eye. All but a very few are called *Fixed stars*, because each of them is always at the same distance from the others, although the whole star-dome, *i.e.* the sky with the stars in it, seems to be moving round slowly overhead. Like the sun and moon, most of the stars rise on the horizon, move across the sky, and set or

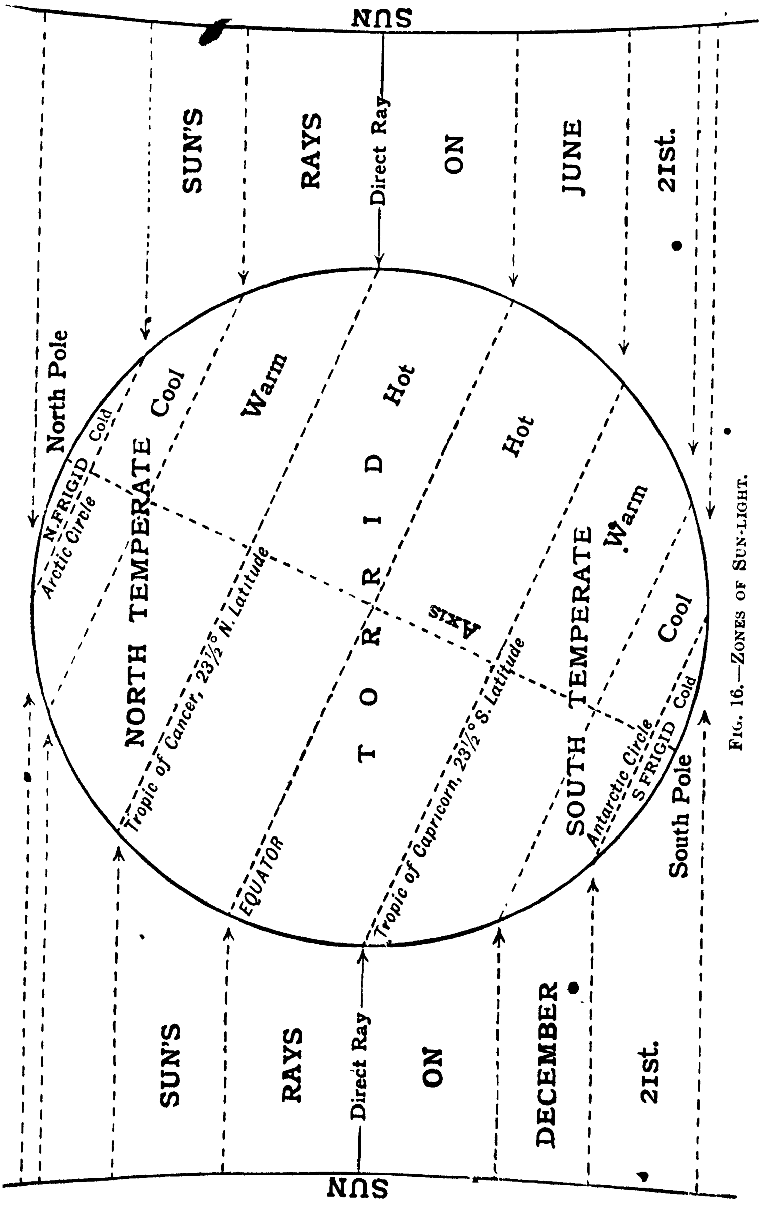


FIG. 16.—ZONES OF SUN-LIGHT.

sink out of sight on the opposite horizon. They do not really move round the earth any more than the sun does. They seem to us to do so because the earth itself is moving round, or rotating on its axis. Some of these stars seem to be arranged in groups or constellations, as seen from the earth, and the ancients gave them names. Two of them they called Cancer and Capricorn, because they thought that the first looked like a crab and the second like a goat with horns.

The fixed stars are countless in number. Although only about 6000 can be seen with man's feeble eyes, a good telescope brings into view some 20 millions more, and with the aid of the most powerful telescopes that have been made, 500 millions of stars may be seen on photographs of the sky. Fig. 17 shows a spot on the sky on which nothing can be seen by the naked eye, not even one star. But, through a large telescope, thousands of stars may be seen at that spot. They look close to one another in the sky just as they do in the figure, but immense distances separate them. The fixed stars are really enormous blazing suns, some of them hundreds of times larger than our sun, all shining by their own light. They are at immeasurable distances from us and from one another, and that is why they look to us tiny points of light. The nearest fixed star is more than 25 millions of millions of miles away from us, and others are at such vast distances that we cannot conceive of those distances, much less measure them. They are all moving rapidly through space, but where they are going we do not know.

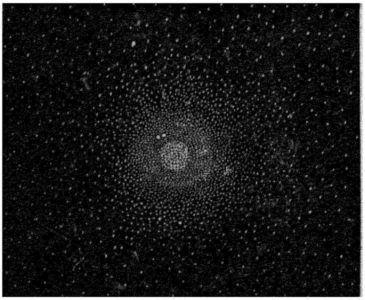


FIG. 17.

A few stars do not twinkle, but shine with a clear steady light like the moon. This is because they are much nearer to us than the rest. They do not keep at the same distance always from one another, but go on changing their places in the sky night after night, and seem to be wandering about among the other stars. The ancients called them *Planets* or Wanderers. They are dark bodies like the earth and moon, and do not shine by their own light, for they have none. They look bright to us because the sun shines upon them, as he does upon the earth and moon, and they reflect his light. They are all spinning balls or globes like the earth; each of them rotates on its axis and revolves round the sun in its own orbit. Five of these planets were known to the ancients, who had no telescopes, and these five may be seen with the naked eye. They are Mercury, Venus, Mars, Jupiter, and Saturn. By the aid of the telescope, two other great planets have been discovered, and more than 600 very small ones. All but two of the large planets have moons revolving round them. The earth is itself a planet, and would look like a planet from a great distance, shining with a clear steady light, and wandering about among the stars.

As the earth and all these planets revolve round the sun, which is immensely larger than all of them put together, they seem to belong to him. The sun (*sol* in Latin) and his planets form what is called the *Solar system.*

The solar system includes eight large planets and 635 small planets. The large planets, in the order of distance from the sun, are:

1. Mercury.
2. Venus.
3. Earth.
4. Mars.
5. Jupiter.
6. Saturn.
7. Uranus.
8. Neptune.

Fig. 18 shows the comparative sizes of the eight planets. Four of them, including the earth, are much smaller than the rest. *Jupiter* is always covered with thick clouds, as shown in the figure, so that the body of the planet itself cannot be seen. It is the largest of the planets, its diameter being about twelve times that of the earth. It has eight moons revolving round it, and it takes twelve of our years to go round the sun once. *Saturn* has ten large moons and is surrounded by "rings" which seem to be made up of countless tiny moons. It goes round the sun in about thirty years. *Uranus* and *Neptune* are at enormous distances from the sun. The former is nearly 2000 millions of miles away, and goes round in about eighty years, while the latter, the outermost planet, so far as is known, is nearly 3000 millions of miles off, and completes its long journey round the sun in about 165 of our years.

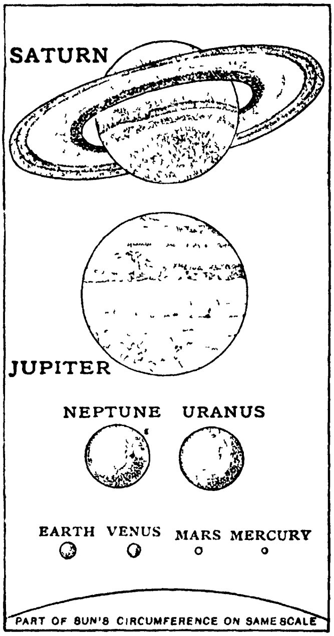


FIG. 18.

Mercury and *Venus* are called Inner planets because, as may be seen in Fig. 19, they are closer to the sun than the earth. All the rest are Outer planets, their orbits being outside that of the earth. Of all the planets *Mars* is most like the earth. On it there are clouds, land, water, mists, and air. On its surface, as seen through the telescope, there appears to be a network of canals full of water.

The *Sun* is one of the fixed stars, the star nearest to us. It is a great globe of blazing fire, of white-hot gas, 500 times as large as all the planets put together. The diameter of the earth is under 8000 miles, the diameter of the sun is over 800,000 miles. It would take 1½ millions of earths to make a globe as large as the sun. Like the earth, the moon, and the planets, the sun rotates on its own axis and does so in 27½ of our days. It radiates light and heat in all directions. The heat and the light which the earth gets from the sun seem to us to be very great. Yet if the total amount of heat and light which the sun is ceaselessly darting forth be divided into 2139 million parts, the earth receives but *one* of these parts (Fig. 20).

So far as we know, the sun, the earth with its moon, and the planets with their moons, were all, at some very far-off time in the past, *one* great body of blazing gases, rotating at enormous speed. One after another, great masses of gas were whirled off into space and each became in time a world, spinning round and round in the same direction as the great ball of gas it had left, and revolving in its own orbit round the parent sun, of which it was at first a part. It has been proved that the sun, the moon, and the planets all contain the same substances or elements, *e.g.* iron, copper, and the other metals and minerals found in the earth, together with carbon and the gases oxygen, hydrogen, and nitrogen, which make up the air on the earth. But in the sun, which is intensely hotter than the other members of the solar system, the metals are gases, so that instead of solid copper,

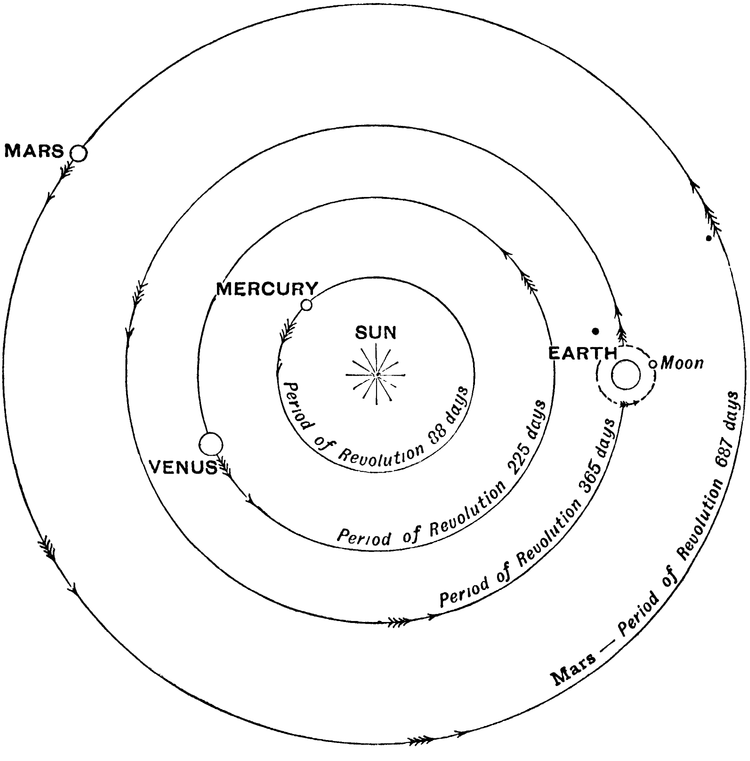

MARS
MERCURY
SUN
EARTH
Moon
VENUS
Period of Revolution 88 days
Period of Revolution 225 days
Period of Revolution 365 days
Mars — Period of Revolution 687 days

FIG. 19.

iron, or carbon, there is in the sun iron gas and copper gas and so on. It is one of the great laws of nature that *heat expands a body*, and that as heat leaves it and *as it becomes cold it contracts* and becomes liquid and then solid. The planets in their turns, one after another, flung off smaller masses of gas, which kept rotating and revolving round them as their moons.

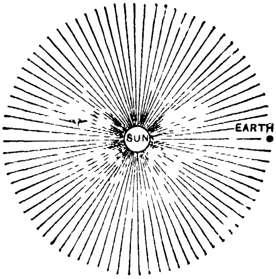


FIG. 20.

The smaller bodies radiated off their heat into space and became cooler than the larger ones, just as a small red-hot ball of iron cools much faster than a very large ball. As they cooled they contracted, and their outer parts became solid or liquid. At first they shone by their own light, as the sun does, but as they lost their heat, they became dark bodies, just as an iron ball does. When white-hot, it is so bright that one can scarcely look at it; when red-hot it is not so bright but still lights up a dark room; and at last, as it cools, it becomes a dark body.

A whirling mass of gas, like what the sun once was, is called a *nebula*. Far off, in the depths of space, the telescope shows us vast whirling nebulae. They, at some distant future, will, no doubt, form new suns, which in their turn will fling off new worlds. Fig. 21 is a photograph of one of these great whirling nebulae countless millions of miles away.

But although the planets were whirled off from the sun with enormous velocity, they could not leave it altogether and rush off into space. The sun kept up its pull upon them from a great distance, and would not let them go. The earth and the other planets too kept up their pull upon their moons, and would not let them go. This *pull* of the sun upon the planets and that of the planets upon their moons is known as the *Attraction of Gravity*. It is one of the great laws of nature and was found out for us by Isaac Newton, the great English astronomer, a little more than 200 years ago. Newton showed that this force acts, not only between the sun and the planets, but everywhere, between all things. All things attract one another. Large things attract small things, and small things attract large things. But the larger a body is, the stronger its pull is, and the closer two bodies are, the stronger is the pull of each upon the other. Solids, liquids, and gases all attract one another. The sun, a great ball of gas, attracts the solid earth; and the moon, as we shall see, attracts the liquid oceans on the earth. The earth, too, attracts the air so that it cannot leave the earth, but keeps close to it.

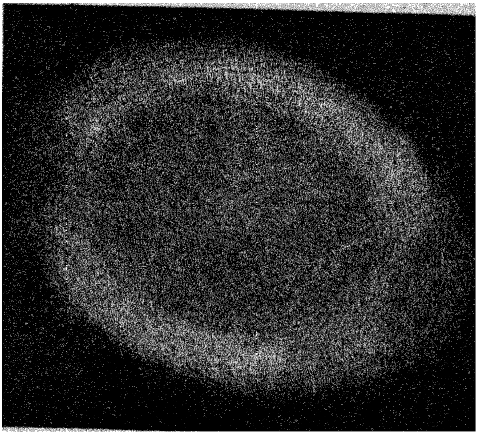


FIG. 21.

Attraction acts at any distance, even over millions of miles, but with much greater force at shorter distances. Halving the distance between two bodies increases the attraction *four-fold*, and reducing it to one-third increases it *ninefold*, *i e.* it increases *inversely as the square of the distance* [$2^2 = 4$, $3^2 = 9$, and so on]. This is why the moon is attracted to the earth and does not rush away to the sun. The sun attracts it, too, and is an immensely larger body than the earth, but the earth is much closer to the moon than the sun is, and therefore its attraction on the moon overcomes that of the sun.

This irresistible force of attraction acts everywhere, even among the most distant stars. The whole solar system, the sun with his planets, is rushing along at the rate of four miles a second, and therefore must be attracted by some larger body somewhere. All the fixed stars, too, are rushing through space. They are all attracted by *something, somewhere.* Where they came from, we do not know. Where they are going, we do not know. That they *are* moving, we *do* know.

Another law of nature discovered by Newton is this. Any body, once set moving by any force, will move on in the same straight line at the same rate for ever, unless it be acted on by some other force. When the moon was whirled off by the earth, it rushed away and would have been lost to the earth, if it had not been for the force of gravity. Two forces were acting upon it, as shown in Fig. 22. The first was the force which whirled it off, when the earth, as a great ball of gas, extended up to the present orbit of the moon. That force alone would keep it moving in a straight line away from the earth towards A. The other force, gravity, would pull it in a straight line to the earth towards B. The moon therefore moved *between* the two. The same two laws act upon the earth and the other planets, and keep them revolving in their orbits round the sun.

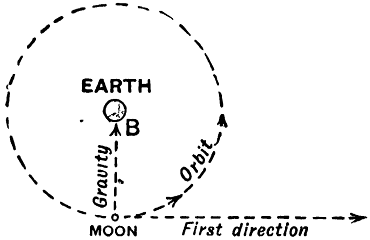


FIG. 22.

EXERCISES.

1. What is the "Solar system"? What is supposed to have been its history?

2. In what ways is the moon—(*a*) like, (*b*) unlike, the earth?

3. How do the fixed stars differ from the planets, and why are the latter so called?

4. Which is the largest and which is the smallest planet? Which is the nearest—(*a*) to the earth, (*b*) to the sun? Which is the farthest from—(*a*) the earth, (*b*) the sun?

5. Which planet do we know most of, and why? Describe its general appearance.

6 About how many stars may be seen from the earth—(*a*) with the naked eye, (*b*) with a very powerful telescope?

7. What is—(*a*) a constellation, (*b*) a satellite, (*c*) a nebula?

8. Say in very simple words what is meant by the "Attraction of Gravity." By what law does it work? Who discovered this law? What other law of nature did he discover? Show how this law affects the orbit of the moon.

9. Say what you know about the sun—its structure, size, and heat.

8. THE MOON.

THE MONTHS.

WE have seen that our year is made for us by the revolution of the earth round the sun in 365 days, and that one day is made by the rotation of the earth on its axis once in 24 hours. The moon makes our months by its revolution round the earth.

It takes the moon about 27 days to go round the earth, and if the earth stood still, this time would make a lunar month. But the earth is moving rapidly along in its orbit round the sun, so that to reach the same point opposite the sun, from which it started, the moon has to travel a little farther every time, and the period from one new moon to another is about 29½ days. This is a *lunar* month. But 12 times 29½ makes 354 days only. To complete the *civil* or ordinary months, half a day is added to some months and a day and a half to others, so as to make up the full number of 365 days.

Like the earth and the planets, the moon spins round on its axis and takes just 29½ days to do so, *i.e.* exactly the same time that it takes to go round the earth. The consequence is that it always turns the same face towards us. The other half no one has ever seen. It may not seem easy to understand how the moon can be forever spinning round and yet never show one half of its face to us. To make this clear, walk round a boy in the middle of the room, always keeping your face towards him, the boy turning round too and looking at you all the time. When you get half round, you will see that any object, *e.g.* a chair, which was behind your back when you started, is now in front of your face. When you get back to your starting-point, you will find that object again behind your back. This shows that you have turned right round, or rotated on your own axis once, while walking round the boy. Yet the boy has not seen your back at all. The boy too has turned right round and yet you have not seen his back as he was rotating.

The light of the moon is feeble compared with that of the sun. It would take 600,000 full moons shining all at once to give us the light of the sun. Once the moon was a ball of blazing gas, shining by its own light, when the earth whirled it off into space. Then it became red-hot, and then dark. It long ago lost its light and its heat. There are huge extinct volcanoes on it. The surface of the moon is solid rock. But there are no seas, no rivers, no air on the moon. There are no animals and no plants or vegetables. It is a dead cold world. To us, however, it gives light by night, and it raises the *tides* on the ocean, which are so useful to sailors.

PHASES AND ECLIPSES.

The moon has a new shape every night of the month. We see it as a new moon, a half moon, or full moon, or of some other shape between these. The different shapes of the moon are called its *phases.* How are they caused ?

The chief of these phases are shown in Fig. 23.

The moon is itself a dark body. It gets all its light from the sun. The sun, of course, can only light up a half of the moon at a time, namely, the half turned towards it. If we are on the same side of the moon as the sun is, we shall see the part lit up by the sun, the bright part. If we are on the other dark side, the moon being between us and the sun, we shall see no moon at all, for it is a dark body in the darkness.

In Fig. 23 the sun lies at the top, out of sight; its rays are seen falling on the earth and the moon. In the centre there is the earth. In the outer circle we see the moon as it is lit up by the sun in twelve positions in its orbit round the earth. One full half is always lit up, being opposite to the sun. This is how the moon would look from the sun. It would be always Full Moon.

In the inner circle, there is the moon in the same twelve positions, as it looks to us from the earth.

At A, the side of the moon opposite to the sun is lit up. As we, on the earth, are on the other dark side, the moon being between us and the sun, we cannot see the lit-up half, in fact we see no moon at all. This is, properly speaking, the *New Moon*, although people often apply this term to the next phase, when a slight crescent or rounded rim of the moon comes into view. At B we are facing the lit-up half and see all of it. This is *Full Moon.* In this phase, the earth, the sun, and the moon are all in one line, the moon being outside and not in the middle, as it is at New Moon. At C and D the moon is half-way between

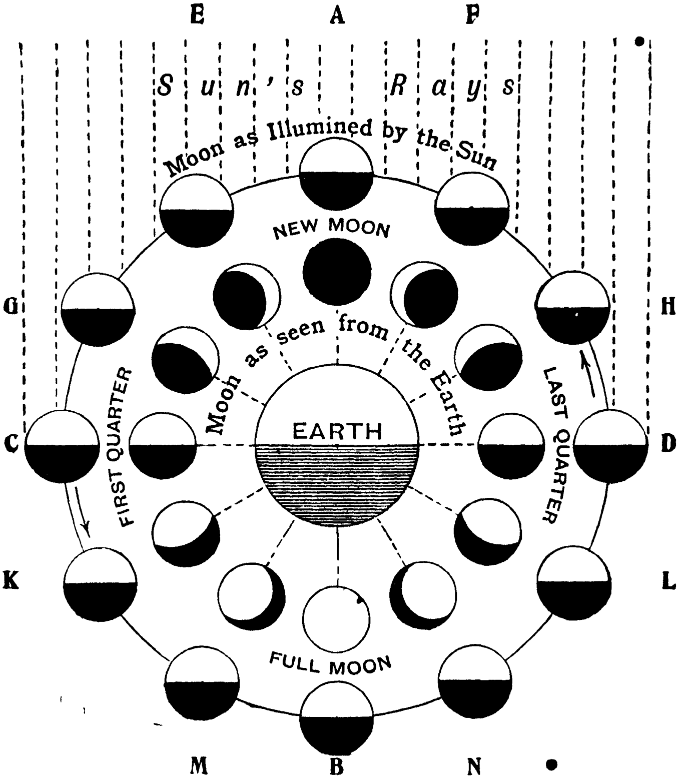


FIG. 23.—PHASES OF THE MOON.

New and Full Moon. We now see just one half of the lit-up face of the moon, these phases being the first quarter and the last quarter (of the lunar month). At E, F, and at G, H, we see *crescent* moons, being so much as is lit up by the sun, the horns or points being turned different ways as the moon is approaching the New Moon or leaving it. At K, L, and at M, N, the shape of the moon is said to be *gibbous.*[1] The lit-up part is getting larger, between a half and full moon at K, L, and a full and half moon at B, M, N.

From the phase of New Moon, the moon is said to *wax* or increase till it is full, and from Full Moon, it is said to *wane* or decrease till it is New Moon, when it vanishes, the half turned towards the earth being altogether in the dark.

The plane of the moon's orbit is the space bounded by the (imaginary) line along which the moon moves round the earth. This plane is not the same as that of the earth's orbit round the sun. It does not lie on the same level. It is inclined to it at an angle of 5°. The plane is, so to speak, a little tilted up, so that one half of it is a little above the plane of the earth's orbit and the other half a little below it. How one plane can be inclined to another and cut it may be seen in Fig. 24. These planes are shaded and look as if they had some thickness. The planes we are describing are mere empty space, and they cut each other as these planes do, but at a much smaller angle.

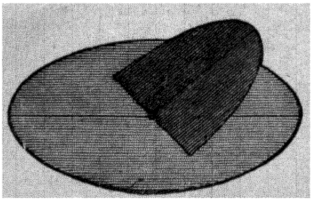


FIG. 24.—A PLANE CUTTING ANOTHER OBLIQUELY.

In Fig. 23, to make the phases very clear, we supposed that the moon moved in the plane of the earth's orbit, *i.e.* the level of the page of the book. But if it did this, every new moon would come between the earth and the sun and shut out the sun from view, *i.e. eclipse* it. And every full moon the earth would come between the moon and the sun and shut out the light of the sun from the moon, *i.e.* there would be an eclipse of the moon. Eclipses do happen, but not once a month.

[1] Latin *gibbus*, a hump or swelling.

At Full Moon the moon is usually just *above* the plane of the earth's orbit, so that the sunlight passes *over* the earth to the moon. At New Moon the moon is generally just *under* this line.

The line of the orbit of the earth (not the plane) cuts the line of the orbit of the moon in two points every month, as the moon passes above the plane and below it. These points are called *nodes*. If the moon happen then to be new or full, *i. e.* in a line with the earth and the sun, we shall have an eclipse of the sun or an eclipse of the moon as in Fig. 25.

Here there is the sun at the bottom of the picture with its rays shooting upward and lighting the earth and the moon above it. The earth is in the middle and the moon in two positions marked A and B. The plane of the earth's orbit is the level of this page. The moon, too, is on the same level, and the plane of its orbit, shown by the circular dotted line, lies on this level.

At A, the moon being between the sun and the earth shuts off the sun's rays and casts a dark circular shadow on the earth, and the people on that part of the earth, on which the shadow falls, cannot see the sun. This is an *eclipse* of the sun. The shadow is never more than above 150 miles in diameter, and never covers any place more than 7 minutes.

At B, the moon is at another point in its orbit on the other side of the earth away from the sun. It is in the shadow of the earth. The circular shadow of the earth creeps over the moon and very soon blots it out altogether. This is an eclipse of the moon. It may be seen at night from the whole side of the earth turned away from the sun. It may last nearly two hours.

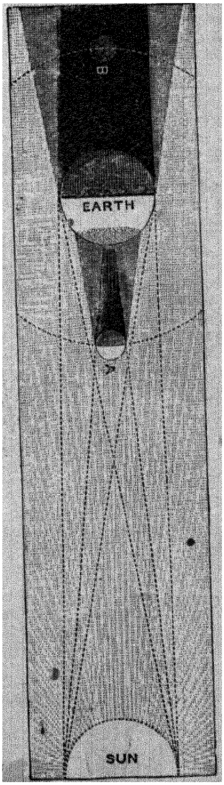


Fig. 25.—Eclipses of the Sun and Moon.

EXERCISES.

1. What makes the months for us?
2. Explain how it is that one face of the moon has never been seen, although the moon is always turning round in full view of the earth.
3. Describe the surface of the face of the moon that we see.
4. What is meant by a "phase" of the moon? What causes—(*a*) a "full moon," (*b*) a "new moon"?
5. Explain the terms: wax, wane, crescent, gibbous, node.
6. How is an eclipse—(*a*) of the moon, (*b*) of the sun, caused—total and partial?

9. THE CRUST OF THE EARTH.

BELOW the soil on the land there is solid rock. Below the bed of the ocean there is also solid rock. This bed of rock is the outer crust of the earth. Fig. 26 shows an imaginary section of the earth from the surface to the centre. On the curved surface of the globe rests the air or atmosphere up to a height of about 200 miles. It is very rare and light high up, but denser and heavier below, where the upper layers press down the lower layers. Then comes the outer crust of rock. How thick it is we do not know exactly. It is *supposed* to be about 10 miles in thickness. It is sometimes called the Lithosphere, or Sphere of Stone (from the Greek *lithos*, a stone). Below it there is the interior or inner part of the earth.

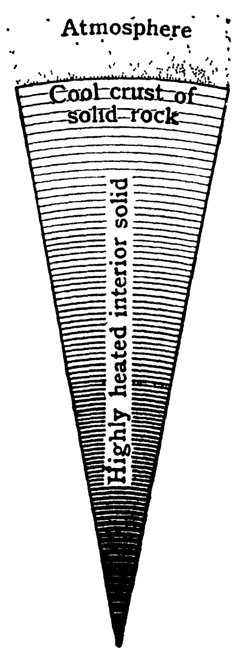


FIG. 26.

The upper layers of the crust of the earth we can see and examine, and chemists and geologists can tell us of what it consists and how it was made. But the interior, which lies far below the outer crust, no one has ever seen or can see. Yet we know two things about it: it is very heavy, and it is intensely hot.

By watching the movements of the moon and the planets which are affected by the gravity of the earth, astronomers can tell with what force the earth attracts them and, therefore, how heavy it is. They have proved that it is about five times as heavy as a globe of water of the same size would be, while most of the rocks which make up the crust of the earth are from two to three times as heavy as water. The earth as a whole is therefore about twice as heavy as rock. It is probably solid, for it seems that the enormous weight of the land, with its mountains, the great oceans, and the rock beneath them, must press it into a solid. Most of the interior probably consists of the heavier metals.

That the interior must be intensely hot, we know from Mines, Wells, Hot Springs, and Volcanoes. *Wells* have been dug to a depth of hundreds of feet, and the deeper the well the warmer the water at the bottom is. In *Mines*, some of which are nearly a mile deep, the air at the bottom is very hot. The deeper the mine, the hotter the air. The heat of the rock into which a mine is dug increases at the rate of about one degree of the thermometer for every 50 or 60 feet in depth. If the heat goes on increasing at this rate, the hardest metals would melt at the depth of 30 miles. *Hot Springs* are found in many countries in the world where very hot water rises to the surface, *e.g.* Bath, in England, has been famous since the Romans ruled England, about 2000 years ago, for its hot springs. Some hot springs are called *Geysers* or "gushers." They are always near volcanoes. In Iceland there are over a hundred of them—huge columns of boiling water are thrown up from 100 to 200 feet into the air, with clouds of steam. They occur also in North America and in New Zealand, always near volcanoes. *Volcanoes* are described in another lesson. They are cracks or openings in the land out of which streams of melted rock and gas and steam are hurled upwards with great force into the air, proving that the heat within the earth out of which they rise must be very great.

Chemists have shown that everything in the earth, the air, and the sea is made up of certain *elements* or of mixtures or compounds of them. All animals (ourselves included), vegetables, and minerals are made up of some of these elements. There are, so far as we know at present, about 75 of them, some being gases, some liquids, and some solids. The names of the elements and their chief compounds may be learnt from any book on Chemistry. Some of the more common are the gases Hydrogen, Oxygen, and Nitrogen, the liquid Mercury, and the solids Iron, Copper, and all the metals; also Carbon, Silicon, and Sulphur. Water (which is a compound of oxygen and hydrogen) is a liquid; if heated, it becomes a gas which we call steam or water vapour; if very cold, it becomes solid ice. If solid iron be heated very much, it becomes liquid, and if heated still further, it becomes a gas. Iron and all the elements are in the sun in the state of gases, and gases they once were in the earth, when it left the sun.

If a large mass of iron be melted in a furnace and then allowed to cool, an outer crust of hard iron slowly forms on the surface and grows gradually thicker, while underneath it the iron is for some time a boiling liquid. The iron cools and becomes solid from the outside inwards. So it was probably with the earth.

Men of science tell us that the earth, at first a globe of blazing gases, shining like the sun by its own light, gradually cooled, as it radiated its heat into space. At first white-hot, it became red-hot, and at last a dark body. At the same time it contracted and at length shrank to its present size. Some of the gases became liquids or solids, or partly liquid and partly solid. Some of the lighter gases mingled and formed the air, or atmosphere, which still surrounds the earth. Many of the heavier liquids (of the heavier metals) probably sank through the lighter liquids towards the centre of the earth. Water covered the surface of the globe on which a solid outer crust or layer of rock—some of it hard, some of it soft—slowly formed. At first very thin, it gradually grew thicker.

Millions of years passed. Under the solid crust, the boiling, bubbling mass of liquids and gases on which it rested began to cool too, and to contract and shrink in size. Parts of the solid crust then began to sink, as the support on which they had rested gave way here and there. Other parts were pushed upwards through the crust wherever there was softer and thinner rock. In this way, parts of the lands slowly rose up through the water and formed continents with their mountains and islands. Great hollows were formed where the crust sank and into them the waters rushed, forming seas and oceans. This rising and sinking of parts of the outer crust of the earth went on through vast periods of time. What was the sea became land, and what was land became sea over and over again. At length, as the ages rolled on, the form or *build* or *relief* of the land became, more or less, what we see, although even now some of the land is slowly sinking and other parts are slowly rising, but the movement is so slow that we who are now living scarcely notice it.

EXERCISES.

1. Explain the terms "lithosphere," "atmosphere.'
2. What is—(*a*) known, (*b*) what is further conjectured, of the interior of the earth? On what facts are these conjectures based?
3. About how many known "elements" are there? Name some of the more common elements.

10. THE CRUST OF THE EARTH (*continued*).

ROCKS.

SOIL.—The upper layer of the crust of the earth we call *soil.* It covers the face of the earth nearly everywhere. In it plants and grasses grow. It is made up of very fine grains of different kinds of stones or rock, mixed with the decaying remains of plants and animals.

SUBSOIL.—Under the soil there is another layer, more or less thick, of *subsoil.* The roots of big trees reach down into it if the soil be not very deep. In it there are stones of the same sort that there are in the soil above it, but the pieces of stone are larger. If the soil be chalky, the subsoil consists of layers of chalk. The soil is merely the upper part of the subsoil that has crumbled away and been mixed with the decaying remains of plants and animals. As the soil is washed away by rain or running water, or blown away by wind, the upper part of the subsoil rises to the surface and gradually becomes soil.

ROCK.—Under the subsoil there lies *rock* everywhere. The subsoil and the soil above it have been formed by the decay and breaking up of the rock that lies below. If the *rock* be chalk, the *soil* is chalky ; if it be limestone, the soil is full of limestone, and so on. We can usually tell from soil what sort of rock lies far below.

In Fig. 27 we see the soil in which grass and shrubs are growing. Below it there is the subsoil, made up of partly decayed rock and small stones. Underneath there are solid rocks. They are in beds or layers which are full of cracks, through which water finds its way, widening the cracks and loosening the beds of rock.

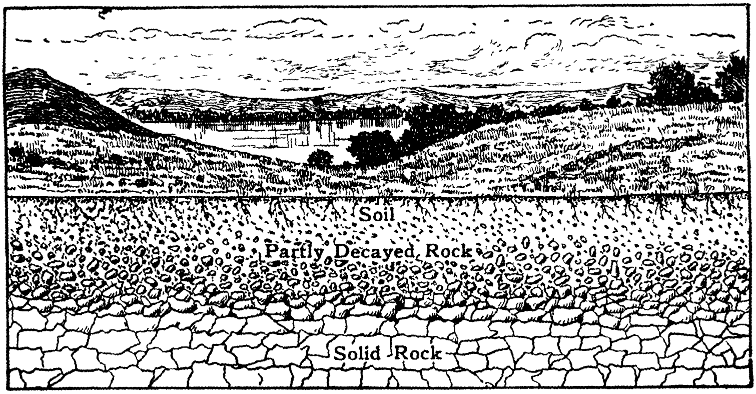


FIG. 27.

The word *rock* usually means hard stone. We say "as hard as a rock." But in geography it has a wider meaning. Everything that is a mineral or metal is rock. It may be sand, or clay, or iron, or chalk, or gold, or slate ; it may be hard or soft ; it may be black like coal, or white like chalk, or of any colour. Mud is rock mixed with water.

If we think of the *matter* out of which rocks are made, we call such as consist of the remains of plants and animals *organic*, for both plants and animals have organs. Chalk, *e.g.*, is organic rock, made out of the shells and bones of once living animals. This can be clearly seen if a little chalk powder be placed under a microscope. The powder is seen to be tiny grains of shells. In many parts of England there are hills of chalk, *e.g.* the Chilterns and the Downs. *Coal* is organic rock, for it is merely the wood of trees hardened into stone.

But if we consider the *process*, or way in which rocks were formed, we may put them all into two groups, as *stratified* (or sedimentary), which lie in strata or beds or layers, as in Fig. 27, and *unstratified*, which are in huge masses or lumps. Stratified rocks have been formed by the action of water. Unstratified rocks have been formed through the action of heat and cold, and are sometimes called igneous (Latin *ignis*, fire). And some rocks which were at first stratified have been so altered or "metamorphosed" by heat or by great pressure inside the earth, that they no longer look like what they once were. They are called *metamorphic* or altered rocks. *Slate*, *e.g.*, is metamorphic rock, for it was altered from clay, which is sedimentary; *marble* is metamorphic, for it has been altered from limestone, which is organic as to material and sedimentary as to formation, and *gneiss* is metamorphic, for it has been altered from granite, which is igneous.

Igneous rocks are the oldest. They formed the crust of the earth as it slowly cooled and became liquid and then solid. The most common of these igneous rocks is *granite*. It lies below all the other kinds of rock, but some of it has been pushed up through them in various places by the earth movements to be described in the next chapter. It is now met with in parts of many mountain chains, *e.g.* the Himalayas, the Grampians, and the Scandinavian Mountains. *Gneiss* is a kind of rock which has been metamorphosed into granite which has been melted and cooled again. It is called *granitic*, and is the most common rock in South India, where there are many huge masses of it known as *Droogs* or hill forts, hundreds of feet high. One of these, 600 feet high, is shown in Fig. 28.

Sedimentary Rock.—If a little muddy water be put into a glass, the mud will slowly sink to the bottom and lie there.

This we call *sediment.* It is also called a *deposit.* We say that it has been *deposited* by the muddy water. In the same way, the gravel, sand, and mud, that thousands of rivers all over the world carry down to the sea, slowly sink through the water to the bottom and lie on the floor of the ocean as sediment. The gravel and sand, being heavier, sink close to the mouth of the river, while the mud, made up of finer earth, is deposited farther away in the ocean. The air is full of dust, although we do not always see it, and this dust falls in vast quantities into the ocean,

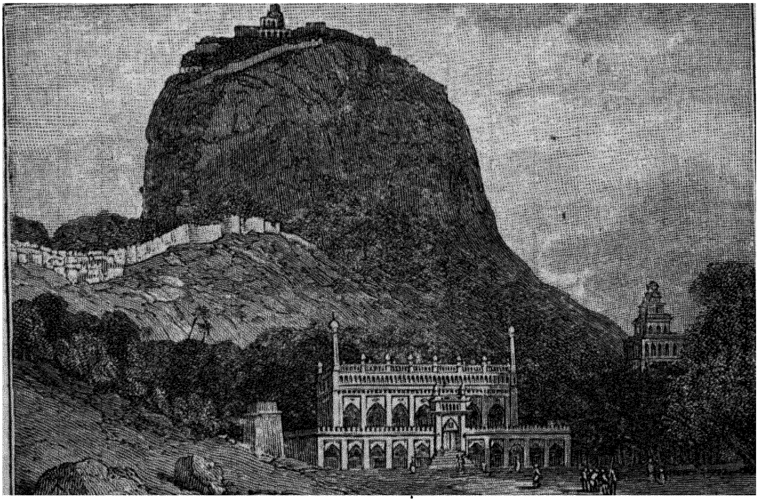


FIG. 28.—A HILL FORT IN SOUTHERN INDIA.

and settles down at the bottom as soft mud called *ooze.* And the ocean is full of countless millions of fishes, many of which live in shells. When they die, their bones and their shells sink to the bottom and lie there. Year after year, age after age, layer is deposited on layer. The upper layers press down the lower layers, and above them there is the enormous weight of the ocean also pressing them down. Slowly they are crushed into solid rock which is called *sedimentary* because it is formed of sediment. It is also called *stratified rock* because it consists of strata or layers. If rock like this was formed from sand, it is called *sandstone.* If it was formed out of clay, it is called *shale* or *slate.* Sandstone is formed near the mouths of rivers, and shale and slate farther out, where the mud was deposited. *Slate* is metamorphic, being merely melted and hardened *shale* which is the hardened sediment of clay. There are slate hills in North Wales out of which great slabs and sheets of slate are "quarried," *i.e.* dug or cut. They are cut into smaller pieces or tiles, and used to roof houses. The sediment of the shells and bones of fishes hardens under pressure into *limestone* or *chalk.*

Lava.—Long ages ago the crust of the earth was not so thick nor so hard as it is now. The liquid rock, under the solid crust, gushed out through cracks in the crust called volcanoes, and flowed over the surface, forming vast layers, sometimes thousands of feet thick, which slowly cooled into solid rock. The Deccan was covered in this way by layer after layer of lava from volcanoes, of which no trace can now be seen. A great plateau was thus raised on the Deccan. Some layers of the lava or volcanic rock were harder than others. The softer rocks have, in the course of ages, been worn away by the rain and wind and rivers; and plains and valleys have been formed in the plateau. The harder rocks remain as hills and mountains, many of which are flat-topped, and have sides which look in the distance like steps or stairs. The rocks which form them are sometimes called *Trap* rocks, from a Swedish word *trappa,* a step. The word Ghats means the same thing, and was given to the Western Ghats for the same reason. The Andes in South America, and the Rockies in North America, were formed in the same way by lava poured out by volcanoes.

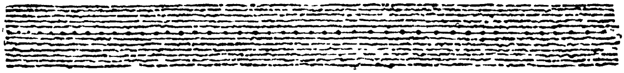


FIG. 29.—SEDIMENTARY ROCK—SANDSTONE.

Coal is merely wood hardened into rock, and is composed chiefly of carbon. In former ages, forests covered the face of the earth in many parts of the world. As they decayed, great beds, often hundreds of feet thick, were formed of their dead trunks and branches and leaves. Then the crust of the earth below them sank, the ocean rolled over them, and they were slowly covered with layers of sand or shells, which hardened into sandstone or limestone rock. The enormous weight of the heavy rock and the ocean above it pressed the layers of plants into hard black coal. After a very long time, that part of the crust slowly rose again, and became dry land. In Fig. 30 we see a deep coal-mine. The coal is shown by the black bands lying between beds of stratified rock, of shale, clay, and sandstone. The three bands of coal were formed at different periods, the lowest being formed first. The long white line going down in the middle is the mine or pit, called a shaft, that has been dug through the rock. At the top of it there is a steam engine. It works the machine which lets down the miners in a cage or large basket, and draws up the coal which they dig out of the mine. Any country which, like England, has rich coal-fields is sure to have large manufactures, particularly if there are iron-mines close by, for the coal is used to feed the furnaces in factories and workshops. In cold countries it is also used as fuel instead of wood, to warm houses

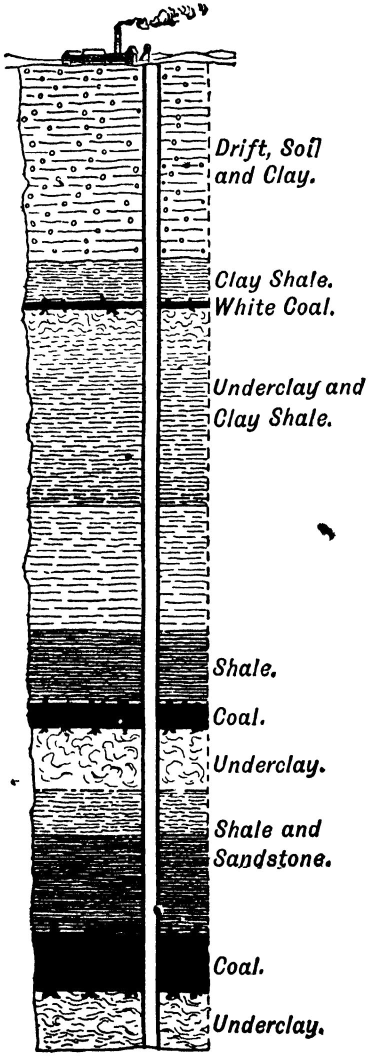


Fig. 30.—A Coal-mine.

and to cook food. Coal-gas is made from coal. It is used for lighting and heating streets and houses, and for cooking.

Petroleum is also called kerosene oil and mineral oil. It is formed, like coal, of the remains of plants, and also of the remains of animals—chiefly fishes. Deep down in the earth there are large beds of this matter, pressed down by the heavy weight above them. If a very narrow well be bored into the layer of oil, the pressure at that point is removed, and the oil gushes up, often with great force. The oil is collected and stored in great iron tanks. It is found in Burmah, the United States of America, Roumania, at Baku on the Caspian Sea, and in other places.

EXERCISES.

1. What is—(*a*) soil, (*b*) subsoil? How has each been formed?
2. What is "rock"? Classify rocks.
3. Describe carefully the formation of sedimentary rock.
4. How has—(*a*) chalk, (*b*) coal, been formed?
5. Why is metamorphic rock so called? Name some common kinds.
6. Describe igneous rocks. Why are they so called? Give some examples.
7. What is lava, and why is it so named? What are (*a*) trap rocks, (*b*) ghats?
8. What is petroleum, and how was it formed? Where is it found?

11. MOUNTAINS.

HOW THEY ARE FORMED.

WE have seen that the crust of the earth is solid rock. Under the soil on the dry land there is rock. Under the ooze or mud at the bottom of the sea there is rock. The rock is not all of one kind. The older or igneous rocks, such as granite, were formed by the cooling of the liquid crust, and the later or sedimentary rocks, such as sandstone and limestone, were formed out of the sand or dust of the older rocks, which were washed off their surface into the sea. We should expect, therefore, to find rocks like granite at the bottom of the crust everywhere, and rocks like sandstone on the top of them. This is so in many places, for most of the rock on the surface of the earth is sedimentary or metamorphic, *e.g.* lava. But in other places we find wide bands or narrow seams or great masses of igneous rock at the surface or near the surface. They seem to have been somehow pushed up from below through beds of sedimentary rock.

In Fig. 31 you see the side and the top of a hill. The soil has been removed and the rock laid bare. Over the letters A, B, C there are strata of sedimentary rock lying in lines. But over I and I′ there is another kind of rock. It is not in strata, but in great lumps which are cracked. It is igneous rock which has been pushed up from below. The mass of rock marked I has not got up to the surface. It divides A from B. Rock I′ has burst through the sedimentary rocks, and divides the block of sedimentary rock D from similar rock on both sides.

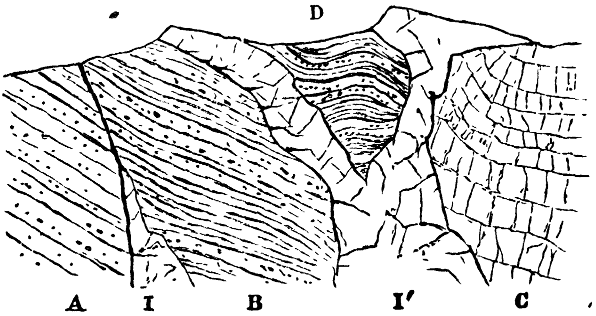


FIG. 31.—SEDIMENTARY ROCK, A, B, C; IGNEOUS ROCK, I, I′.

What force pushed up this igneous rock from below? Why are these strata of sedimentary rock at the top of a hill? How did they get up there from the bottom of the sea where they were formed? Why are they tilted up on one side instead of lying quite straight as in Figs. 29 and 30? To answer these questions, we must find out how hills and mountains were formed.

When a solid body sinks into a liquid or half-liquid mass, it pushes it aside, and the liquid rises up all round the sinking solid.

The earth was once, as we have seen, a huge globe of blazing gas. As it gradually cooled, the outer crust became boiling liquid rock made up of all the elements, some light, some heavy, some losing heat rapidly, some cooling slowly. In time the liquid rock became solid, but very slowly. Different parts solidified at different rates. Some parts of the crust became solid before other parts, which were still liquid or half-liquid, like glue or melting wax. As great blocks of the more solid and heavier rocks slowly sank into the softer mass around them, they pushed it up on all sides, and in course of time it became solid too. The crust of the earth was then all igneous rock, but not all on the same level.

Into the wide hollows in the crust, formed by the sinking solids, the water rushed and formed seas and oceans. The half-liquid stuff which had been pushed up became hard rock and formed the dry lands, the continents, and islands. Through vast periods of time, rain fell on the rocky land and fierce winds blew over it. At length soil was formed, and forests grew up. Rivers rolled over the land, and the running water cut away the softer rocks and formed deep, wide valleys, while the harder rocks remained as hills and mountains. This process is called *erosion*, *i.e.* eating away; or *denudation*, *i.e.* laying bare. Rain, wind, running water, and frost are the chief "eroding" or "denuding" agents. The process is also known as *weathering*, but this term is usually applied to a rock or cliff which has been worn smooth or is crumbling away under the action of the weather, *i.e.* the wind and the rain, or the beating of the waves on rocks on the seashore. A plateau or raised block of land which, like the Deccan, has in course of time been worn down by erosion into hills and valleys is sometimes said to be *dissected* or cut asunder. And mountains and hills formed in this way are often called *Old mountains*, as they were the first to be formed. Other mountains were formed in another way, as we shall see.

For thousands and thousands of years, enormous quantities of stone were washed off the surface of the land, and carried down by the rivers into the sea, and there became sedimentary rock.

What would happen where *two or more* heavy solid blocks of rock sank into the soft yielding mass of half-liquid rock around them? The soft rocks would be squeezed together between the hard blocks. They would be pressed together from both sides. There would be enormous *lateral* or side pressure on them. They would be squeezed upwards, but the top layers of this soft rock would not be level. Any layer of soft matter, if it be pressed on both sides, will rise up in the middle into folds or ridges. In Fig. 32 you see, on the left-hand side, some sheets of cloth pressed down by two stones laid upon them. They lie flat on the table. On the right-hand side, there are the same sheets being pushed or pressed together on both sides. You see how they rise up into folds or ridges in the middle.

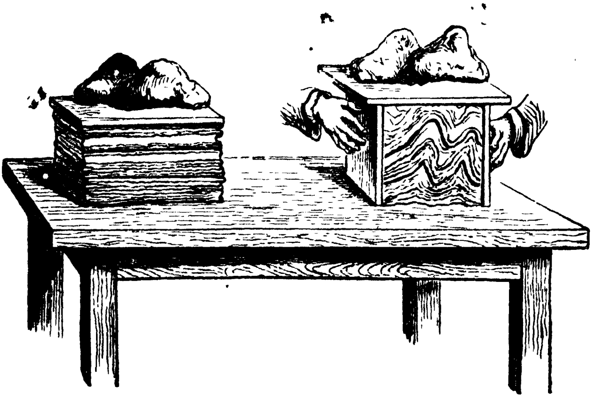


FIG. 32.—EFFECT OF LATERAL PRESSURE.

Compare this picture with Fig. 33, which is a section of a part of the Alps in Switzerland. You see how these great mountains look like the sheets of cloth pressed together in Fig. 32. Like the cloth, they have been under enormous lateral pressure. The stratified rocks which once lay flat, horizontally, at the bottom of the sea, have been pushed up into huge folds, now mountains, and have been tilted up so that they now lie in a nearly vertical or upright position.

This, then, is a *second* way in which mountains have been formed, viz. by lateral pressure due to the cooling and contracting of parts of the *outer or upper* crust of the earth. The mountains formed in this way are called *Folded* mountains, because they were pushed or *thrust* up in huge folds of rock. They were formed, probably, millions of years ago, but they are young mountains compared with still older mountains of igneous rock. Like them, they too have been exposed for long ages to erosion, and are being gradually worn down, and carried by running streams into the valleys, or away to the sea.

Folded mountains are also formed in another way. The

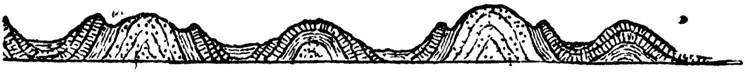


Fig. 33.—Section of a Part of the Swiss Alps.

cooling of the earth has never stopped. In the course of ages, the *lower* layers of the earth's crust began slowly to cool and contract, and, while so doing, they *pulled* together with enormous force the upper layers which rested on them. Parts of the upper crust were slowly pushed upwards in great folds or ridges.

If several layers of clay be pressed firmly down upon a thick sheet of india-rubber stretched out forcibly beneath them and the rubber be let go, it will at once contract to its former size and pull together the layers of clay. The result of this force of contraction is shown in Fig. 34. The upper layers of clay are pushed up, as you see, into folds or wrinkles. The topmost layer is cracked across in several places.

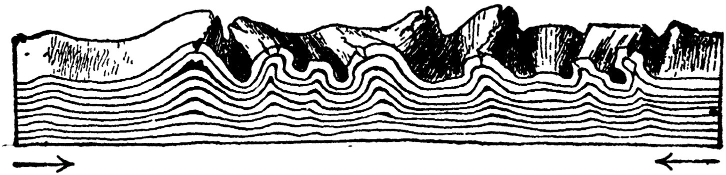


Fig. 34.—Contraction of Clay on India-rubber.

Just so, the contraction of the lower layers of the earth's crust forced the upper layer into huge folds or ridges, which are now great mountain ranges like the Himalayas, and are called Folded mountains. The topmost layer of rock in the upper crust cracked in long lines, and through these cracks great volumes of gas and boiling rock, known as lava, burst out from the interior of the earth. The cracks in the crust are called volcanoes.

In Fig. 35 you see a section of the Himalaya Mountains. The whole of this part is sedimentary rock, which once lay at the bottom of the sea, as may be seen from the long lines of strata. Once they were level horizontal layers. But they were pushed up into ridges or folded mountains by the force of contraction. At *a* the strata are still nearly level, but at *b* and *e* they have been tilted straight up on end, and from *e* to *f* they have been twisted up and down like the cloth in Fig. 32. At *e* there is a great crack in the crust of rock.

This is the *third* way in which mountain ranges have been formed, viz. by the contraction of the *lower* layers of the earth's crust, which forced up the bottom of the ocean in some places, and low-lying plains in other places, thousands of feet into the air, forming folded mountains, which are young mountains compared with the more ancient mountains already described. They are loftier than the old mountains, their peaks are more pointed, and their sides and cliffs are steeper, because the agents of denudation—the rain, the wind, and the frost—although they are always at work, have not yet had time to wear them down like the older mountains.

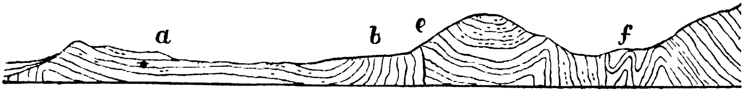


FIG. 35.—SECTION OF THE HIMALAYA MOUNTAINS—SIMLA RANGE.

The *fourth* way in which mountains are formed is by the overflow of lava from volcanoes. This raises what are known as *Volcanic* mountains, which will be described in the next lesson.

Hills are lower than mountains and have been worn and weathered down from mountains. Hills are in fact very old mountains. The common phrase, "as old as the hills," may remind us of this. The term "hill" is sometimes limited to heights of 1000 feet to distinguish them from mountains, but this rule is not always kept.

Exercises.

1. What kind of rock would you expect to find uppermost on the crust of the earth, and why?
2. Can you explain how it is that rock made out of the shells of fish are found on the summits of the Himalayas, 20,000 feet above the level of the ocean?
3. In what different ways have mountains been formed?
4. Explain the following terms: Erosion, weathering, dissected plateau, folded mountains, lateral pressure.
5. How were—(*a*) the Alps, (*b*) the Himalayas, formed?

12. VOLCANOES AND GEYSERS.

A *Volcano* is a conical-shaped mountain formed of igneous rocks. When molten rocks with gas, steam, ashes, and dust are thrown from the interior of the mountain, the volcano is said to be in eruption. The molten or liquid rock is called *lava*. The mouth of the crack looks like a great round hole in the ground. It is called a *crater* or cup. When the lava flows over the sides of the crater on to the ground, it slowly cools, and after a while it becomes solid rock. As stream after stream is poured out all around, a hill, shaped like a cone, is gradually formed. The hill gets higher and higher and becomes a mountain which is often thousands of feet high. **Cotopaxi** is a giant mountain in the Andes in South America, which rises about 19,500 feet above the sea. It has been built up out of lava. Its upper part of 3500 feet is a cone covered with snow. Out of the crater at the summit, hot ashes and dust and stones are from time to time hurled high into the air and scattered all over the land around it.

Fig. 36 shows what the inside of a volcano would look like, if it were cut asunder. There is a passage or chimney in the middle, going down deep through the crust of stratified rock, to the liquid rock below. There is the black lava bursting up into the air with clouds of steam, and the crater at the summit of the

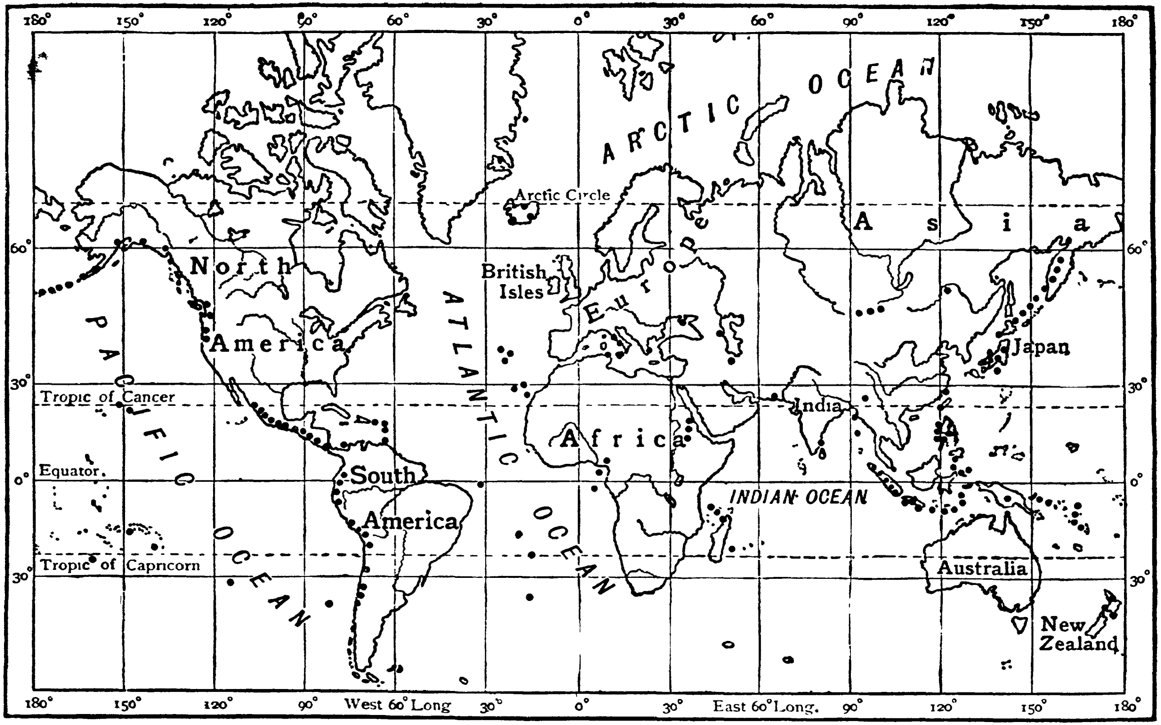


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FIG. 38.—CHIEF VOLCANOES OF THE WORLD MARKED WITH BLACK DOTS.

of the sea, from the bottom of lakes, from the beds of rivers, from the land on which rain falls, water is always finding its way deep down into the crust of the earth where it is intensely hot, so that the lower the water goes, the hotter it gets. At last it boils and becomes changed into steam. When the pressure of the steam upwards is greater than the downward pressure of the weight of the rocks which lie above it, it bursts upwards, like the steam in a kettle, which lifts the heavy iron lid, and would blow it off if it were fastened down. As the steam rushes up, it carries with it molten rock or lava and gases. The bursting out of the lava is called an *eruption.* One of the best-known volcanoes of the world is **Vesuvius** in Italy.

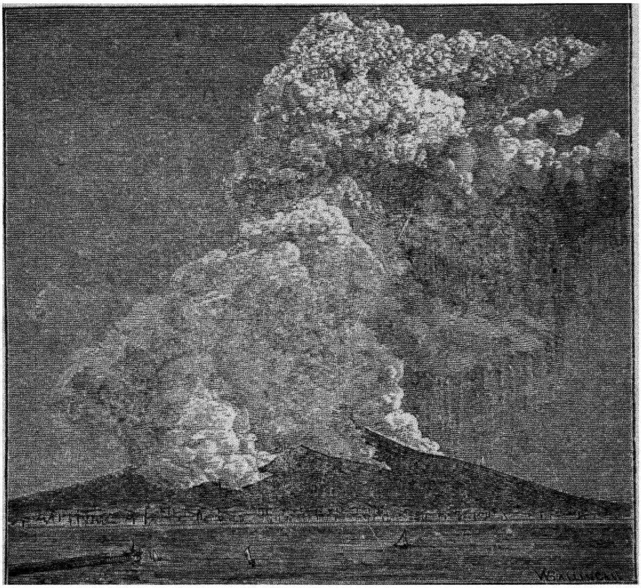


FIG. 37.—VESUVIUS IN ERUPTION.

In an eruption of Vesuvius, great clouds of glowing gas and smoke and black dust and steam burst upwards hundreds of feet into the air, and streams of lava follow. The steam condenses into water as it rises into the cold air and falls in showers of rain. The clouds along the sides of the hill in the picture are

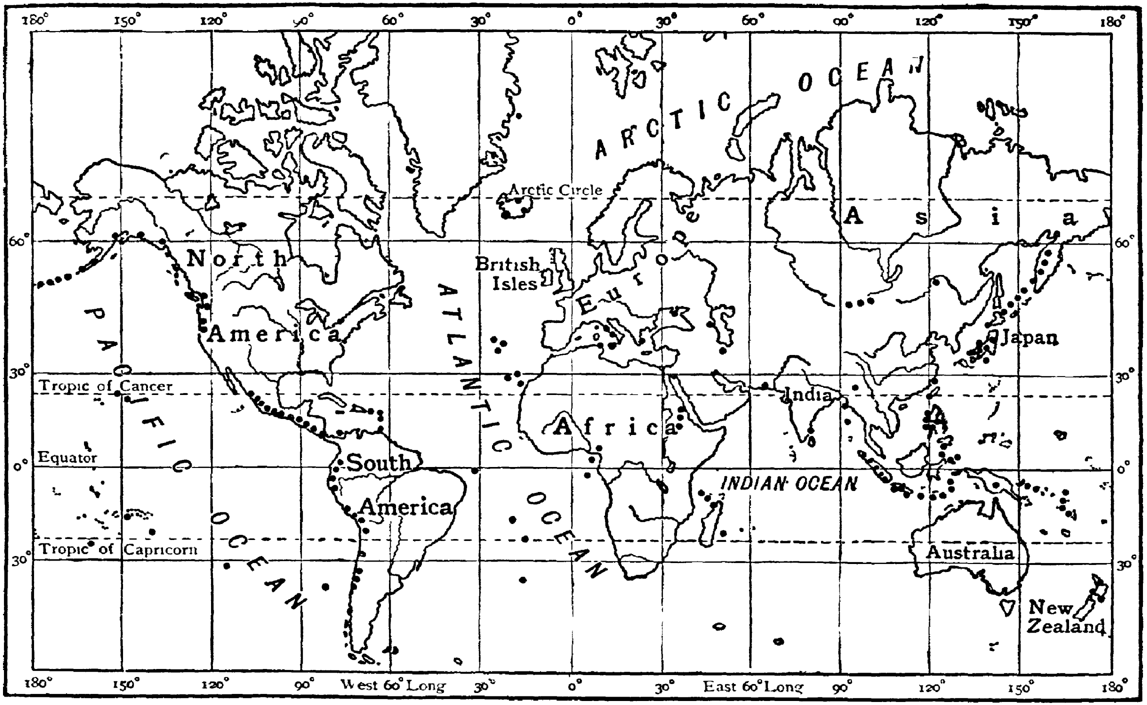


FIG 38.—CHIEF VOLCANOES OF THE WORLD MARKED WITH BLACK DOTS.

the steam and smoke rising from streams of lava flowing down from the crater.

In some volcanoes, the eruption ceases when the steam has spent its force. The crack in the earth may get choked up and the sides may fall in, and the crater fill up in course of time. The volcano is "silent." If no eruption has taken place within the memory of man, it is said to be extinct. In distant ages in the past, when the earth's crust was thinner and softer than it is now, there were probably many more active volcanoes than there are at present. Extinct volcanoes are found all over the world, and even where there is now no trace of a volcanic mountain, the lava, which makes the soil, shows that volcanoes were active there at some past period.

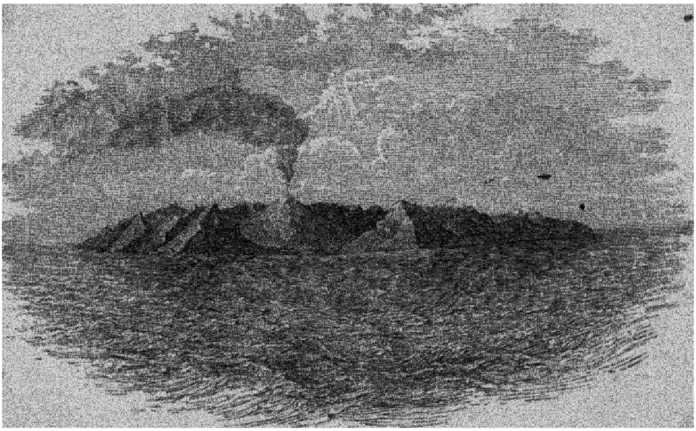


FIG. 39 —BARREN ISLAND.

In many places, volcanoes are ceaselessly in action. In the Mediterranean Sea, the great island volcano, **Stromboli**, lies in the route of steamers from Port Said in Egypt to Marseilles in France. Stromboli, a huge mountain of lava, rises out of the sea to the north of Sicily. Smoke is nearly always rising from one of the craters on it, and streams of lava may be seen flowing down its sides into the sea **Etna**, an active volcano in Sicily, is more than 10,000 feet in height.

Many of the volcanoes of the world are found in long lines on the borders of the Pacific Ocean, along the western coast of America and the eastern coast of Asia. They are in ranges of mountains or on islands which are really the summits of mountains rising out of the sea. The map on page 56 shows where the chief volcanoes of the world lie. The lines mark deep cracks or fissures in the crust of the earth, reaching down to the molten rock below. In the map, the black dots mark the volcanoes. There is a long line of these dots along the great ranges of the Andes, the Cordilleras of Central America, and the Rockies of North America. The volcanoes in the Andes are still active, but those in North America are extinct. The line of active volcanoes is seen again in the peninsula of Alaska and the Aleutian Islands. It continues down the coast of Asia along Kamchatka, the Kurile Islands, Japan, Formosa, and the Philippine Islands. Another belt of volcanoes runs through Sumatra, Java, and the Sunda Islands.

In the Indian Ocean, among the Andamans, lies the solitary volcano known as **Barren Island.**

The belt is continued eastwards through New Guinea and other groups of islands to New Zealand, and seems to end in this direction in Mount Erebus, a great volcano on the Antarctic continent.

The islands in the Pacific are all volcanic, except the Coral Islands, which were formed in another way. In many of them there are active volcanoes, *e.g.* the Sandwich Islands. The Fiji Islands are extinct volcanoes.

A short line of volcanic islands occurs in the West Indies, some of which are still active. There is another line down the great rift valley and the mountains on the east coast of Africa (p. 56). **Kilimanjaro,** in this region, is a great volcanic mountain.

If the map showing these lines of volcanoes be compared with that of the great world ridges on p. 63, it will be seen that a large part of the mighty ridge which goes round the land mass of the globe is volcanic.

There are many other volcanoes which occur singly. Elburz in the Caucasus, Mount Ararat in Asia Minor, the Azores, the Madeiras, the Canary Islands and Teneriffe, Ascension Island, Mauritius, and St. Helena are all volcanic.

Geysers.—Much of the water that sinks into the earth gushes upwards through cracks in boiling springs. Water and steam burst out at intervals, and rise sometimes in fountains to the height of one or two hundred feet. They are called in Iceland geysers, *i.e.* "gushers" or "roarers." They are long cracks like pipes which go deep down through the rock to pools of intensely hot water below. They are usually found near volcanoes, and are common in Iceland, New Zealand, and the "Yellowstone Park" in the United States, where there is a famous geyser known as "Old Faithful" which bursts out about once an hour.

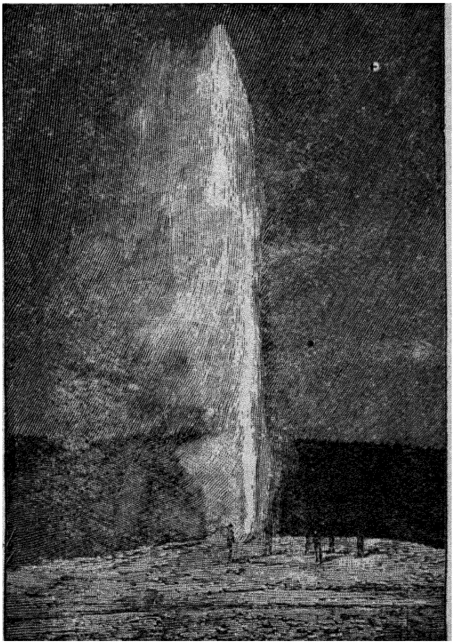


FIG. 40.—"OLD FAITHFUL" GEYSER.

EXERCISES.

1. What are volcanoes? How were they formed? Why are they so called?

2. What forces cause an eruption?

3. Explain the terms (*a*) crater, (*b*) extinct volcano.

4. Name and give the position of—(*a*) the chief ranges of mountains formed by volcanic action in Asia and America, (*b*) some single active volcanoes.

5. What are geysers? Why are they so called? Where are they found?

13. EARTH MOVEMENTS.

EARTHQUAKES.

WE saw in Lesson 9 that, millions of years ago, parts of the crust of the earth sank, and oceans filled the hollows thus formed. Other parts rose, forming continents and islands. This rising and sinking, these *slow movements* of the earth, were very gradual, and were repeated through vast periods of time. They are often termed "*secular*" or age movements. The lands of ancient time sank and became sea, and the ancient ocean beds were upheaved and became dry land again and again.

Even now these slow movements are going on, for the earth is still cooling, but the movements are so slow that men living in any one age do not notice them. We know that the level of the land is being raised in some parts of the world, because we find beds of shells of sea animals, like those now living in the sea, embedded in the sides of cliffs on the sea coast, at heights from 100 to 1000 feet. They were once under the sea or on the sea-level. They never moved from the land in which they were then fixed. The land itself has moved slowly upwards to its present height. And in many countries there are raised beaches along the coast. They have marks on them to show that the sea once rolled over them. Pebbles and rocks worn down by the sea-waves are fixed in them. They now lie in flat stretches of sand from 50 to 100 feet above the present level of the sea. In Fig. 41 the land has risen at least four times, as the lines of the sea-strands on the sides of the wall show. Each line marks the level of the sea. In some places there are ancient buildings, which we know were once on the sea-level, now standing on land high above the sea.

On the other hand, the level of the land in some parts is slowly sinking. On the coast of England trees, which grow only on land, may still be seen under the water, proving that the land has sunk and so the water has covered them. It is believed that the *fiords* or deep inlets of the sea on the coast of Norway, the similar inlets on the south-west coast of Ireland, and those on the north-west coast of Scotland are "*drowned valleys*," that is to say they were once deep river-valleys on the land, down which rivers flowed into the sea. But the sea, owing to the slow sinking of the valleys, filled or drowned them.

Some of the coral reefs and islands in the Pacific and Indian Oceans are slowly sinking. The coral cannot live below a depth of about 180 feet, but the coral formation has been found at a depth of 1800 feet below sea-level. Darwin, the famous scientist, suggested that the submarine mountains seem to have sunk gradually while the coral continued to build on the summits; this is known as the *subsidence* theory. In some cases, however, coral islands have been elevated high above sea-level. An *atoll* or coral island is a ring of coral rising out of the deep sea. It is only about a quarter of a mile broad. The rough waves break on its outside face. Inside there is a lagoon or shallow lake of still salt water.

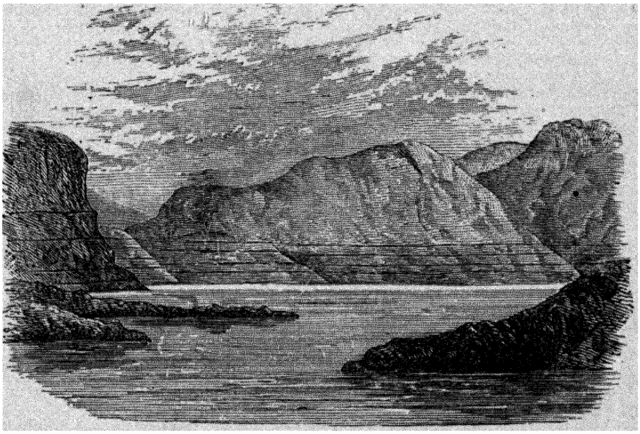


FIG. 41.—RAISED SEA-STRANDS.

Besides these slow movements of the earth there are often *sudden* movements of the rocky crust in different places. These are called EARTHQUAKES, *i.e.* earth shakings. A part of the surface suddenly moves up sometimes an inch or so, sometimes a few feet. In Chile in South America there was a great earthquake in 1822, when 100,000 square miles were suddenly lifted about 4 feet. In Cutch, in India, there was an earthquake in 1819, when 2000 square miles of land suddenly sank a few feet and the sea rushed in and covered it. At the same time a long strip of land 50 miles long and 10 miles broad rose 10 feet. Earthquakes usually occur in volcanic regions, and are caused in the same way and by the same movements as fold or crumple the rocky crust of the earth into mountains. Sometimes the ground seems to rock to and fro, and sometimes a slight earth-wave is felt like a low wave of the sea. Buildings are thrown down and many people killed by a severe earthquake.

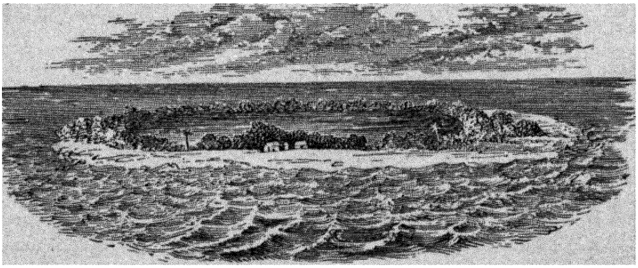


Fig. 42.—Coral Island.

Exercises.

1. Describe some "secular" movements of the earth. Why are they so termed?
2. Prove from observed facts that much of the earth's surface has been—(*a*) raised above, (*b*) depressed below, its original level.
3. What are—(*a*) "drowned valleys," (*b*) fiords? Give examples.
4. Describe the formation of a coral island.
5. What is an "earthquake"? How is it caused?

14. CONTINENTS, WORLD RIDGES, AND WATERSHEDS.

In Fig. 43 we see the great land masses of the globe, *i.e.* the continents and large islands, with the huge ridges we call mountains, rising above the face of the land, and the oceans which lie all round them.

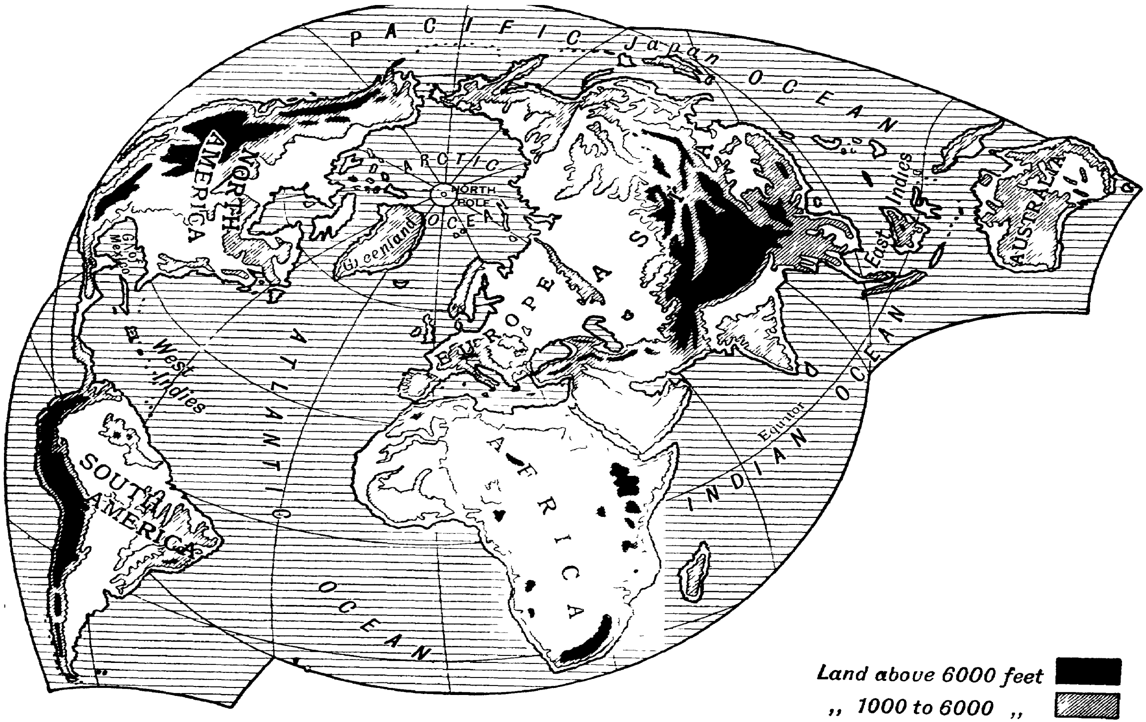


FIG. 43.—GREAT WORLD RIDGES.

Arrangement of Land and Sea on the Surface of the Earth.—The *first* point we notice is that there is much more water than dry land on the surface of the earth. There is about two and a half times as much sea as there is land. Look also at Figures 44 and 45.

Secondly, most of the land lies north of the Equator, *i.e.* in the northern hemisphere, in which there is about thirteen times as much land as there is in the southern hemisphere. The great masses of land lie in a vast semicircle or curve like a horse-shoe, most of which is in the northern hemisphere, with the Atlantic Ocean in the middle and the Pacific Ocean outside.

Thirdly, three of the continents, North America, South America, and Africa, are triangular in shape. These great triangles have wide bases to the north and taper down to a point in the south. The vast continent of Eurasia, *i.e.* Europe and Asia, appears to be broad rather than long, like the others. But nearly all its southern countries are peninsulas which are more or less triangles, pointing to the south. India is quite a triangle, and Spain, Italy, the Balkans, Arabia, Burma, Siam, and the Malay Peninsula all point southwards. There are, it is true, a few exceptions, *e.g.* Denmark, Yucatan, and Labrador, but the general rule is that all the land masses are broad in the north and taper down southwards.

Fourthly, the broad northern bases of North America and Eurasia and Greenland form an inner horse-shoe or ring of land around the Arctic Ocean, the North Pole being in the middle. From this northern base the land stretches away in continents southwards. In ancient times, Europe and Africa were one great continent. No strait then separated them. Animals could pass from one to the other. There was no Mediterranean Sea. The mountains of northern Africa are the same in build as those of southern Europe, and were probably formed at the same time.

Fifthly, around the North Pole there is the ocean. Around the South Pole there is a continent called Antarctica, recently discovered. It is covered by a huge sheet of ice.

The word *Anti-podes* means "opposite (our) feet." Those who live on the opposite side of the globe to us are our antipodes. The antipodes of any piece of land or water is the land or water lying directly opposite to it on the other side of the

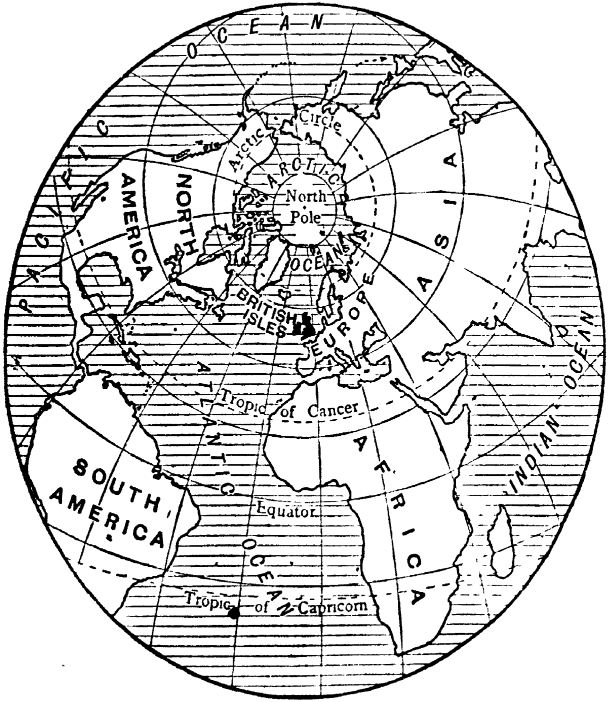


FIG. 44.—LAND HEMISPHERE.

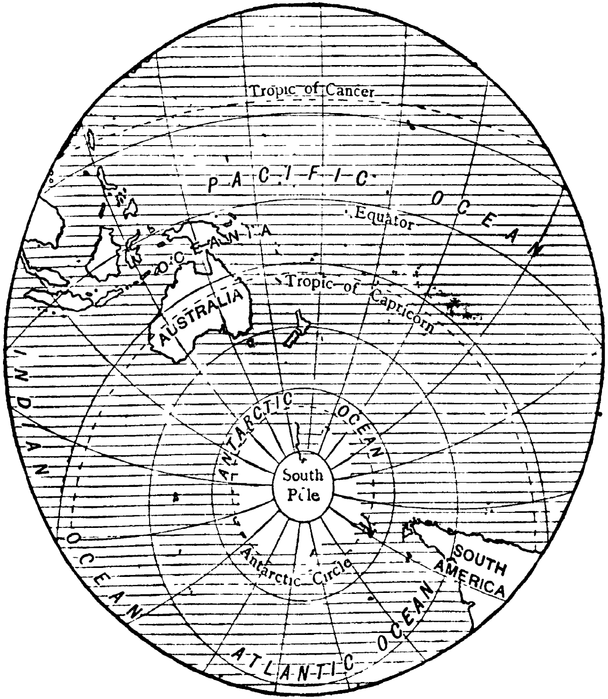


FIG 45.—WATER HEMISPHERE.

globe. Figs. 44 and 45 are two hemispheres called land and water hemispheres. They are made by drawing two circles round the globe, so that one half of the surface may have as much land in it as possible and the other as much water as possible. These Figures show what is called the "antipodal arrangement" of land and water. The antipodes of any point in either of these hemispheres is in the other. It will be seen that the antipodes of land, in nearly every case, is water, and the antipodes of water is land.

These Figures also show that the British Isles with London are very nearly in the centre of the land hemisphere, and that New Zealand, which is almost their antipodes, is very nearly in the centre of the water hemisphere. The situation of London is one reason why it has become the centre of the world's commerce and the largest city in the world.

The Great World Ridges.—Now let us turn again to Fig. 43. We see two great world ridges. One is a mighty mountain range which stretches, like the nails round a horse-shoe, along the outside of the great land masses for thousands of miles. It is called the Andes in South America and the Rockies in North America, and runs north and south for a distance of some 9000 miles along the western coast, forming, so to speak, the backbone of these continents, which run in the same direction, north and south. It is continued right up to the north-eastern corner of Asia. From that point it runs for some 9000 miles farther, down long lines and groups of islands on the eastern coast of Asia, the Aleutian and Kurile Isles, the Japan and Loochoo Isles, the Philippines, and Borneo, to New Zealand. These long lines of islands are the summits of mountains which once formed one long ridge or range like the Andes. They have sunk, so that their slopes are hidden by the waters, and their bases rest on the bottom of the Pacific Ocean. If, now, we look at Fig. 38, we shall see that this is the great *volcanic* range of the world. It marks a great crack in the rocky crust, up which lava gushed for long ages and piled up huge mountain ranges.

The other great world ridge is known as the Alpine-Himalayan system of mountains. Its general direction is east and west across the great continent of Eurasia. It is so called because it includes the Alps in Europe and the Himalayas in Asia. It extends, for over 12,000 miles, from the mountains of Spain, in the south-western corner of Europe, to the north-east of Asia, along the south of Europe and the centre of Asia. Here it divides into a northern and a southern branch, which uphold between them the huge block of elevated land known as the plateau of Central Asia and Tibet. Branches run off from the main range in many directions. They are all true *folded* mountains, formed in the way described in Lesson 12. They were squeezed up by the sinking of the earth's crust to the north and to the south. To the north the sinking is marked by the great plains of the north of Europe and Asia, and to the south by the still deeper hollows now filled by the sea.

Great World Watersheds.—It will be seen that the lie or direction of the continents follows the direction of the great mountain ranges. In each of the continents there is an *Axis* or *Watershed* or "*Divide*" or *Water-parting*. All these terms are used to denote a crest of rising ground from which the land slopes down on either side to the sea. This axis need not lie in the centre of the mass of land nor need it lie on the highest mountains. It is the line of *average* height of the land and it is marked by the way in which the rivers flow down each side of it. On any map the direction of the rivers shows the slope of the land. The great axis or watershed of South America lies close to the Pacific coast, just as in India the watershed of the Deccan lies along the Western Ghats. In both, short rapid rivers flow down the western slope and long rivers flow slowly down the eastern slope. In Europe, the *Divide* runs through the chain of the Pyrenees between France and Spain, the Alps, the Carpathians and the Caucasus up to the Caspian Sea. When the axis is in the middle of a country, the length of the slope on both sides to the sea will be about the same. But when it lies close to one side, the slope is short and steep on the sea side and long and gentle on the opposite side, as it is, *e.g.*, in South America. The steep side is called the *scarp* or the *escarpment*. In South America the crest of the watershed runs along the lofty summits of the Andes at a distance of from 50 to

100 miles from the Pacific Ocean. The scarp falls sheer down from 10,000 to 20,000 feet on this side. But on the opposite side there is a long slope of 2000 miles to the Atlantic. In the Deccan, the western scarp of the Western Ghats is from 3000 to 7000 feet steep, and the slope at its base is from 10 to 50 miles wide, while the opposite slope runs down for hundreds of miles to the Bay of Bengal.

Secondary Watersheds.—It will also be seen, from the physical maps of the continents in this book, that where the main axis of a continent is on one side, *e.g.* in South and North America, a second watershed or mountain ridge runs down the opposite side, fronting the smaller ocean. In North America this secondary ridge is seen in the Alleghany and Appalachian Mountains, in South America in the Sierras of Brazil. In South India this line is marked by the Eastern Ghats. When continents have highlands on both sides, like this, there are wide plains or low plateaus between them. In North America there are the great plains of Canada and the prairies of the Mississippi. In South America there are the Pampas, the Selvas, and the Llanos. It was, in fact, the sinking of these plains on the one side and the still deeper sinking of the ocean plains on the other that cracked the crust of the earth and forced up the mountains between them by lateral pressure from the east and the west.

EXERCISES.

1. What is the proportion of sea to land on the earth's surface?

2. Looking at the map, say on what part of the surface most of the land lies.

3. Compare the various continents in respect of their general shape.

4. Describe, generally, the supposed arrangement of the land-masses and the oceans in bygone ages, before they had their present positions.

5. How does the surface of the earth at the North Pole differ from that at the South Pole?

6. Explain the term "antipodes." What are the antipodes (most nearly) of the British Islands?

7. Describe the two great "world ridges" and the world watershed.

8. What is a "secondary watershed"? Describe one—(*a*) in America, (*b*) India.

15. RIVERS AND THEIR WORK.

How Water circulates.

The sun shines upon the ocean, the water is warmed, and vapour rises into the air. The winds carry the vapour over the land till they come to rising ground, to hills or mountains. The winds blow up the slopes of the hills and soon reach colder regions of the air. There the water-vapour condenses into clouds. As the clouds are carried upwards into still colder air, they condense into rain. The rain falls on the hills and runs down the slopes as a river into the plains below. The rivers flow on to lower ground till at last they reach the sea. The fresh river water mingles with the ocean water. Once more it evaporates, and goes through the same round of changes as before

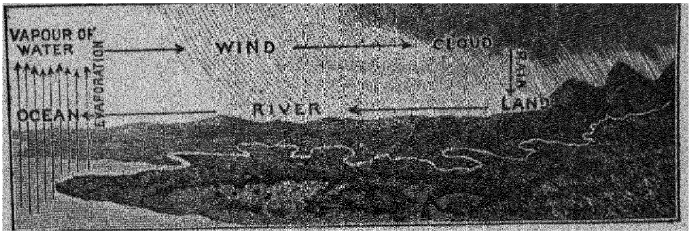


Fig. 46 —Circulation of Water.

This going round and round, this "circulation" of water, may be seen in Fig. 46. The arrows pointing upwards from the ocean on the left, show the rising vapour. The upper arrows pointing towards the land show the direction of the wind. Then come the black clouds and the rain falling from them on the hills. The long white line below meandering over the land, in the direction of the lower arrow, is the river flowing down to the sea.

The water in the world never stands still. It is true that we cannot always see it moving. We can see the clouds move across the sky, and we can see the rain falling. We can see the rivers rushing down to the ocean. But the water on the quiet surface of a lake seems to be standing quite still. Yet, from the surface of the lake, invisible vapour is always rising into the air, and if no rain fell, or if no stream fed the lake, all the water in it would soon disappear. It would have travelled upwards to the clouds. Immense quantities of rain fall into the sea too, and countless rivers flow into it, and yet the sea never overflows. It loses as much water by evaporation as it gains from the rivers and the rain. The total amount of water in the world remains the same; only it is sometimes in the air, sometimes in the sea, and sometimes on the land.

The *Source* of a river is sometimes said to be in the clouds, and this is in one sense true. But the term "river" is usually applied to water flowing over the land. Its source is where it rises or begins to flow. A river may rise in a spring or a lake, or at the foot of a glacier or field of ice, below the snow-line, where the heat of the air is enough to keep the ice always melting.

Springs.—Part of the rain which falls on the earth runs off to lower levels, but part sinks into the soil. Below the soil and the subsoil, the water finds rock. If the rock be loose or porous like sandstone or gravel, the water sinks through it, till it comes to a bed of rock like clay, through which it cannot pass. It finds its way along the surface of this bed till it comes to open ground, often the side of a hill, when it "springs" or gushes out, as in Fig. 47. The water flowing down from it is called a brook, or rill, or rivulet. Lower down it becomes a river, after it has been joined by other brooks.

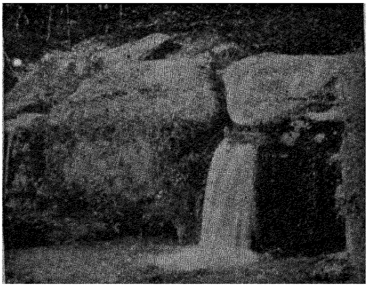


FIG. 47.—SOURCE OF A RIVER—A SPRING.

The *Course* of a river, from its source to its mouth, where it flows into the sea, may be divided into three stages, *upper*, *middle*, and *lower*. If we look down a river with our backs to the source and our faces towards the mouth, the bank on the right is the *right* bank, and that on the left, the *left* bank. The *tributaries* of a river are the smaller rivers flowing into it; they are also called *affluents*.

The Kennet is an affluent or tributary of the Thames. The spot where one large river joins another is called their *confluence*, *e.g.* the confluence of the Kennet and the Thames is at Reading. The country drained by a river and its tributaries is its *basin*, a tract of land which slopes down towards the river in every direction. The rising ground dividing two river basins is termed a *watershed*.

The *work* done by the running water of rivers is of three kinds. They are : *Erosion*, or the wearing away of the banks and beds of rivers ; *Transport*, or the carrying down of earth, stones, and rock which have been eroded; and *Deposition*, or the dropping of the material eroded and transported, on their own beds, or on the land around them (when in flood), or into a lake or into the sea.

The first part of the *Upper Course* of a river, sometimes called the "*Torrential Track*," is usually down the steep slope of a hill, often a mountain side. Here the brook changes into a torrent, as in Fig. 48. If it rise in a lofty mountain range, as the Himalayan rivers do, *e.g.* the Indus and the Ganges, this part of its course is often a series of *Waterfalls*, where the water falls from one ledge of rock to another. When the water rolls rapidly over a long slope, the fall is known as a *Rapid*, or *Rapids*. Several falls, one after another, as in Fig. 48, are called a *Cascade*.

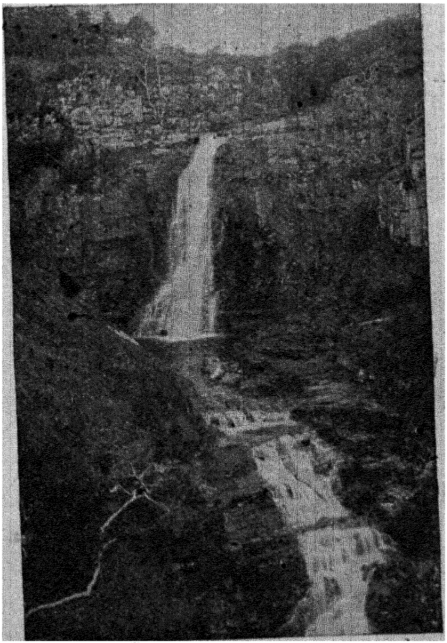
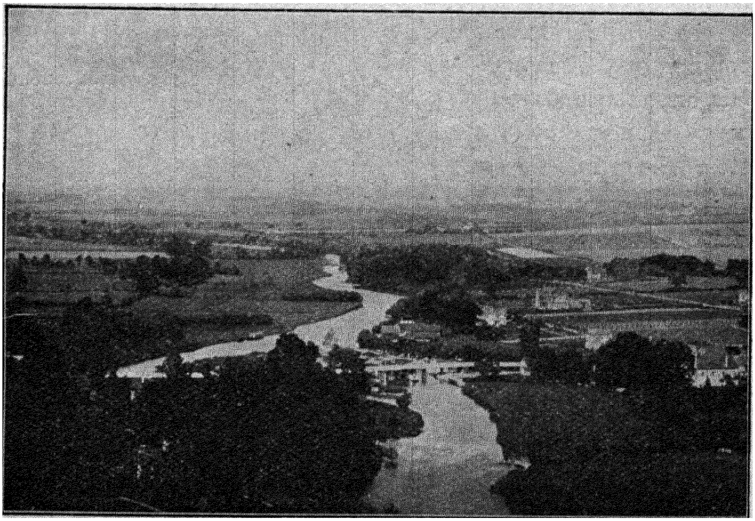


FIG. 48.—A TORRENT

The next stage in the upper course of a river is often called the *Valley Track*. Here the river rushes down through a valley, over the more gentle slope that lies along the base of a mountain range, at the rate of 3 or 4 miles an hour. It carries down with it rocks, stones, and earth. The larger rocks and stones are broken into smaller pieces as they knock against one another and rub against the stony bed of the stream, and are worn down into smooth pebbles and rounded gravel. As it rushes onwards, the water wears away the sides of the mountain valley or gorge through which it flows, and makes it wider and wider. The hardest rocks, in the course of ages, yield to this erosion or eating away of their surfaces by running water. Owing to the steepness of the bed and the swiftness of the flow of the stream, very little material is deposited on the bed of a river in its upper course. It is nearly all transported to the lower level. Because of the force of the rushing water the upper course is never navigable.



Photo, H Taunt & Co

FIG. 49.—MIDDLE COURSE OF A RIVER. THE THAMES AT STREATLEY HILL.

The *Middle Course* of a river is over a plain, and is sometimes termed the *Plain Track*. Here the water spreads the material that it has brought down from the upper course over the surrounding country and forms plains. The plain was once a river valley, but the sides of the valley have been weathered down by the wind, the rain, and the running water, acting through a long period of, say, 100,000 years or more. The bed of the river has been raised by the earth and the stones brought down from the hills in the distance. In time of flood, when the rain has been very heavy, or when the melting snow has filled the river to overflowing, the mud and soil transported from the hills have been spread all over the country, forming a "flood-plain." This soil is called *silt* or *alluvium*, and a valley like this is an alluvial valley. The overflow of the Nile in Egypt has covered the banks with alluvial soil.

The course of a river is never straight like the line of a canal. The stream always flows along the lowest ground it can find, and winds in and out to avoid any rising ground that may be in the way. A very winding river is said to *meander*, like the ancient river Meander in Asia Minor.

Change of Course.—Sometimes such vast quantities of silt are brought down by a river that the bed is raised up to the level of the banks. Then the river rushes away to the lower ground below one bank or the other and forms a new channel—many miles away, it may be, from its first channel. This often happens with the Indus and the Brahmaputra. The Hoangho, in China, broke its banks in 1852, flooded the country, and at last flowed into the Gulf of Pe-chi-li, 300 miles away from its former mouth in the Yellow Sea.

The *Lower Course* of a river is its last stage before it flows into the sea. In the upper course the slope is steep and its flow rapid. Very little sediment is dropped. Where the river enters the plains, the slope is much less, the flow is slower, and a great deal of silt is deposited both in the bed of the river and over the country around it. The volume of water in the river is increased by the tributary streams that join it and bring down fresh silt with them. In its third and final stage the slope is a plain nearly flat. There must be a slight slope or the water would cease to flow. It is often called a ***Pene-plain***, a term which means "almost a plain," as the term peninsula means "almost an island." As the river meets the sea, its flow is checked, and it drops the silt, the earth, and the mud that it has brought down with it into the sea, close to the land.

If the mouth of the river is in a land-locked bay, the layers of earth deposited one above another, year after year, for thousands of years, form a bank that rises above the surface, and the river divides into two streams, one on each side of the bank. A new bank is formed in the same way, and the river again divides as in Fig. 50. More silt is washed up on the sides of the banks, and at length firm land is built up. The land formed in this way is called a *delta*. The first land to be called a delta was that at the mouth of the River Nile in Egypt. It is a great triangle, like the Greek letter delta, Δ, and received its name for that reason.

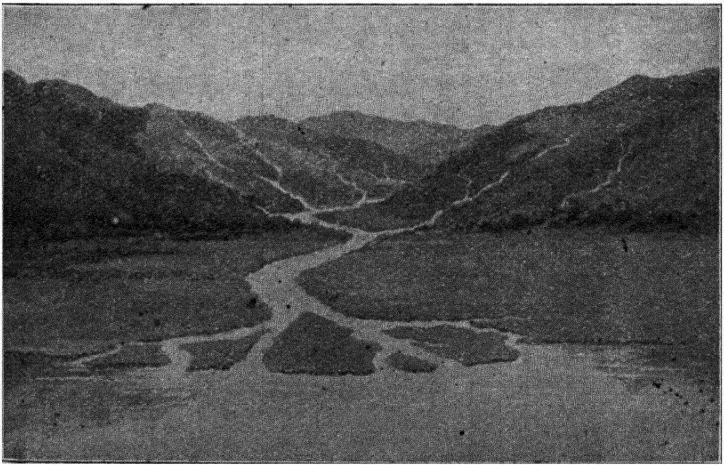


FIG. 50.—MOUTH OF A RIVER—DELTA.

Ages ago the Nile flowed into the Mediterranean Sea, at the point where Cairo now stands. The country between Cairo and the sea, a distance of 100 miles, is made of the alluvium that has been gradually deposited by the river. The length of the outside of the delta, or the coast between the dotted lines, is about 200 miles, and the depth of the alluvial soil is quite 120 feet. All this enormous mass of soil has been brought down by the Nile from Upper Egypt. Well may Egypt be called the "gift of the Nile."

In this way great rivers build up large tracts of country at their mouths. The coast-line at the mouth of many great rivers bulges out into the sea. This may be seen in the physical map of India, at the mouths of the Irrawaddy, the Kistna, the Godavri, and the Mahanadi. All the broad rice-fields of Bengal have been formed out of the mud and silt which have been deposited by the Ganges in the sea which once covered them.

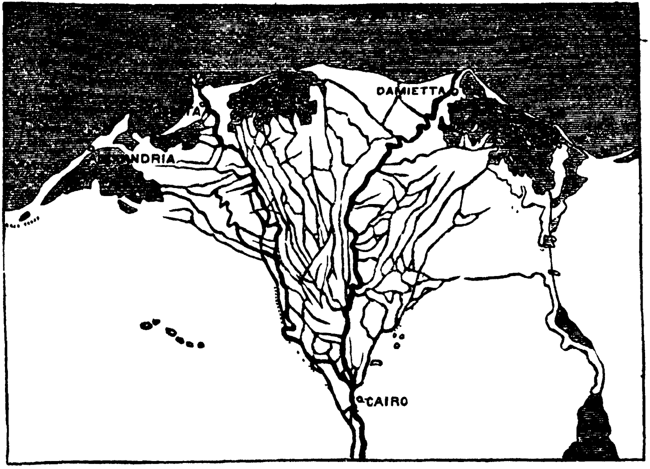
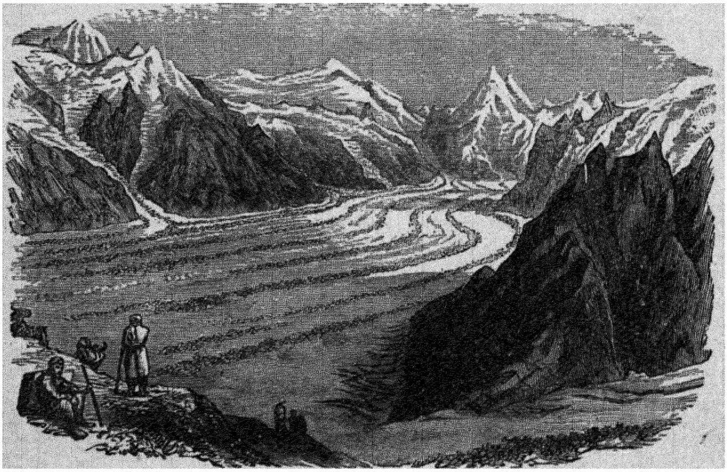


FIG. 51.—DELTA OF THE NILE.

Glaciers, Rivers of Ice.—Above the snow-line the snow never melts. On the summits and higher slopes of lofty mountain ranges snow collects in great heaps above this line. The upper layers press down the lower layers into a huge solid mass of ice, which slowly moves down the mountain slope as a "glacier" (so called from the Latin *glacies*, ice). This "river of ice," however, does not flow down the mountain side like a river of water. A torrent of water rushes down at the rate of about 20 miles an hour, a river in the plains flows along at the rate of about a mile and a quarter in the same time; but a glacier only moves a few feet, often only a few inches, in a day. The glacier moves downwards till it gets below the snow-line, to a point where the air is warm enough to melt it. Then a stream of muddy water flows from it and is the source of a river. The Rhone flows from a glacier in the Alps.

Fig. 52 is that of a magnificent glacier in the Karakorum range to the north of the Himalayas. It is 36 miles long, the longest in the world. On the left rises the lofty snowy peak known as Karakorum, 28,278 feet high. The hotter the season, the more the snows melt and the fuller the rivers get. When the rainfall is added to the water from the snows on the hills, there are floods in the river, which often overflows its banks. The stones and gravel which become embedded in the ice form long lines called *moraines.* In Fig. 52 they are clearly seen. From the vast glaciers which move down, in Polar regions, to the ocean, huge masses of ice break off and float away to the south as icebergs, some of them 200 feet high. The banks off the coast of Newfoundland are supposed to have been formed by the earth and stones which drop into the sea when the icebergs slowly melt in the warmer water of the Gulf Stream.



H Godwin-Austen.

FIG. 52.—GREAT BALTORO GLACIER, KARAKORUM MOUNTAINS.

EXERCISES.

1. How does water "circulate"?
2. What is meant by the statement that the source of the Thames is in the clouds?
3. Describe the origin and formation of a spring.
4. Describe the different "stages" of a river. Illustrate your description by referring to any well-known river.
5. In what various ways do rivers mould the surface of the land?
6. Describe rapids, cascades, cataracts.
7. Explain and exemplify each of the following terms: (*a*) valley track, (*b*) alluvium, (*c*) confluence, (*d*) affluent, (*e*) basin, (*f*) pene-plain, (*g*) meander.
8. Describe some famous deltas. How has each of them been formed?
9. What is a glacier? Describe its formation. Which is the longest known glacier in the world?

16. VALLEYS AND PLAINS.

OLD AND YOUNG.

THE first river valleys were the channels cut by running water in the surface of the old igneous rocky crust of the earth. Like mountains, valleys may be old or middle-aged or young.

These three stages in the life of a valley—youth, middle age, old age—correspond with the three stages in the course of a river—upper, middle, lower; for valleys are made by rivers. As soon as a stream ceases to be a torrent racing down a steep mountain side, its upper course is along a valley which it carves out for itself, it may be on a lofty plateau or it may be through cliffs which lead down to a plain below. This is a young valley.

The growth of river valleys in a plateau may be seen in Fig. 53, which shows how a valley gets wider and deeper from age to age. The line along the top is the surface of the plateau as it was when the river began to flow over it. The line at the bottom shows the level of the same land when it has been worn down by the river flowing over it for thousands and thousands of years. It is now a low-lying plain. All the land which once lay above it has been carried away by the river and deposited in the distant ocean, into which the river flows.

The V-shaped cut AA′ shows the first valley formed. The sides are steep. This is a new-born valley. No water is shown in Fig. 53, but you must imagine that a swift stream is flowing along the bottom of the V. Thousands of years afterwards, the shape of the valley is the deeper and wider cut going down between B and B′. This is a young valley. The wide stretch from C to C′ is the same valley in middle age, where the sides have widened still more and the bed is deeper. The space from D to D′ is an old valley, very wide and deep.

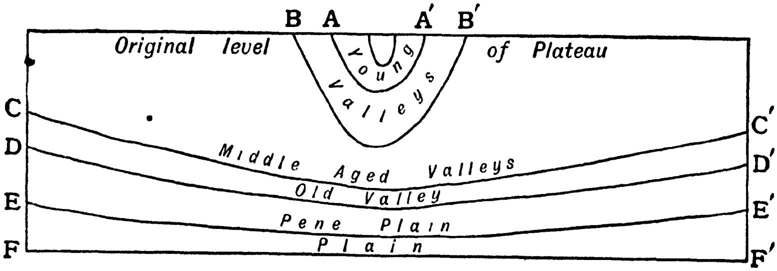


Fig. 53.—Growth of Valleys.

The line E to E′ is a still older valley, which now looks like a plain. It is called a pene-plain. The line FF′ is the base level to which the plateau has been worn down. It is a plain.

All this time the rain and wind and the carbonic acid in the air have been busy. As the river has been deepening its bed at the bottom of the valley they have been wearing down the sides, eroding the rocks, which have gradually crumbled and fallen into the river below and been carried away by the running water. The river is like a man digging away at the bottom; the wind and the rain are like men digging away at the sides. Between them, working through long ages, and never stopping work for an instant, they remove the whole of the great block of land.

The same stages in the life of a valley may be seen in the following pictures.

A very new valley in its earliest stage is a mere mountain gorge like that in Fig. 54, through which a river has forced its way. It is deep and narrow, and the sides are still steep cliffs. It will take ages for these cliffs to wear down and for the valley to widen out. But the end is certain though it is still in the distant future. These cliffs will be worn down to the ground and the valley will become a plain.

In a middle-aged valley, like that in Fig. 55, the once lofty mountains have weathered down into low hills; their steep and jagged peaks and sides have been worn smooth by the "agents of denudation," the wind and the rain. The river, which has made the valley, has lost its supply of water as the hills have become lower and lower. It is now a narrow stream, winding along over the alluvial soil which, in ages long gone by, it brought down from the mountains. These hills will in course of time disappear, as they have vanished from the valley in Fig. 56, and the valley will become a plain.

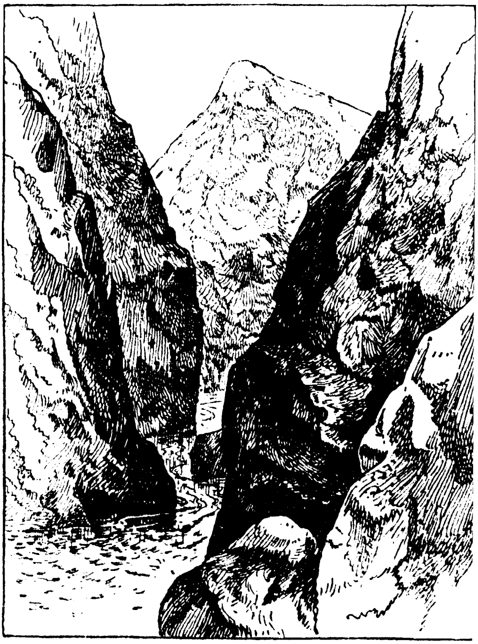


Fig. 54.—A Mountain Gorge.

The oldest valleys are those which are the flattest, for the sides of the valley have been quite worn away by the weather.

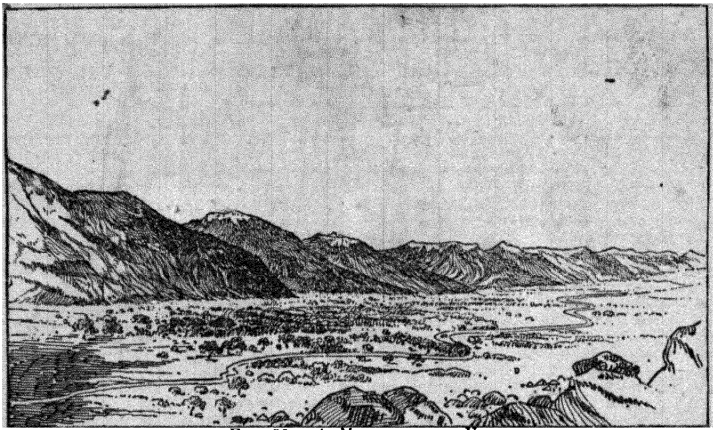


Fig. 55.—A Middle-aged Valley.

The very hills have disappeared, and with them the rivers in which they took their rise, and the valley in its old age has become a plain. An old river valley is often filled, to the

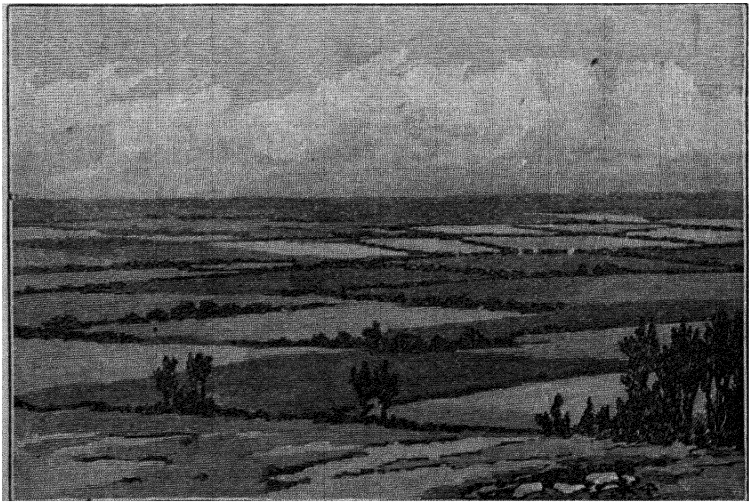


Fig. 56.—A very Old Valley, now a Plain.

depth of hundreds of feet, by *alluvium*, washed down by the river and its tributaries from distant hills. The great plain of northern India is an alluvial valley filled with the soil brought down into it by the Ganges from the Himalayas on the north and by other rivers from the Vindhyas on the south.

Great Plains of the World.—The great flat lands on the surface of the earth have been formed in different ways. Some of them lie at a low level, and to them the term *plain* is usually applied. Some lie at a high level, and they are called *table-lands* or *plateaus.* The surface of a plateau is not so level as that of a low-lying plain. Hills often rise across it or around it, or on the side of it.

When the rocky crust of the earth was cooling down from a liquid into a solid, great flat blocks were slowly upheaved as the surface rose, or were left standing as the tracts around them sank. The vast plains in the north of Europe and Asia were probably formed in this way. So were the wide plateaus of Central Asia and Tibet. They are *upheaved plains.* The latter rises 13,000 feet above the level of the sea between two mighty mountain ranges, the Kuen-Lun and the Himalaya.

Some of the plateaus made of softer rock than the rest were "dissected," worn down, and converted into river valleys by the action of running water, and these valleys were slowly changed into pene-plains, or plains, in the way already described. They are *River plains.*

The *Coastal plains* that lie along the coast of many countries, *e.g.* India, were made by the sediment brought down to the sea by large rivers and hundreds of small streams and deposited there. The flat banks thus formed gradually rose to the surface, and formed a long plain at the base of the hills along the coast. Other coastal plains have been made by "marine erosion," *i.e.* by the wearing away of the coast by the ceaseless action of surf upon it. The waves of the ocean beat upon their shores with great force and form a beach which is often miles wide.

In North America, vast plains stretch from the Rocky Mountains on the west to the Alleghany and Appalachian Mountains on the east (see map, No. 11). On it there are many ridges of low hills and lines of valleys, but it is, as a rule, level. It includes the enormous pene-plains called *Prairies*, now watered by the Mississippi and its tributaries. They are so flat that the rivers are navigable for a distance of about 4000 miles from the sea. In South America (see map, No. 13) there are the vast plains or *Llanos* of the Orinoco, the *Selvas* or forest plains in the basin of the Amazon, and the *Pampas* in the basin of the La Plata. More than half of Europe is one immense plain, which sweeps across the north of France, Germany, Belgium, Holland, and Russia. It extends into Asia and forms the great northern plain of Siberia in that continent, a tract from 1000 to 1800 miles broad and about 4000 miles long. Round the Caspian Sea the plain is known as the *Steppes*, and in the north of Siberia as the *Tundras*, which slope towards the Arctic Ocean for 400 or 500 miles. It is so cold that not even grass grows; the surface of the earth is covered with moss. China and northern India are wide alluvial river-plains.

The African continent is made up of table-lands, from which ranges of mountains rise. In northern Africa there is a wide barren region known as the *Sahara*. It is a long, broad plain, rising here and there into hills and low table-lands. It is covered with dry shifting sand where little or no rain ever falls. It is one of the great deserts of the world.

Australia is, for the most part, a table-land in the west and a wide arid plain in the centre.

EXERCISES.

1. Describe the three stages in the life of a valley.
2. How have the great plains on the earth's surface been formed?
3. Describe and give examples of: Plateaus, upheaved plains, desert plains, coastal plains, dissected plateaus.

17. THE ATMOSPHERE.

WHAT AIR IS.

ABOVE the surface of the earth, over land and over sea, there lies an ocean of gas and vapour, though we cannot see it. It is called the *Atmosphere* or vapour-sphere—the *Air*, which is the "region of clouds, rain, snow, hail, lightning, thunder, breezes, storms and tempests." We live at the bottom of this ocean of air, as fishes live in the ocean of water, and we should die if we were taken out of it, as fishes die out of water.

As the earth cooled down from the gaseous into the liquid state, the air was formed by the mixture of two of the elements, Nitrogen and Oxygen, both of them gases. About four-fifths of the air is nitrogen and one-fifth is oxygen. The oxygen in the air supports life and heat, but we could not breathe pure oxygen. Nitrogen dilutes or weakens it and so makes it fit for us to breathe. Without oxygen we could not live. Without oxygen nothing would burn. These two gases make air. But in the air, and mixed with it, there are other things as well, although we cannot see them. The most important of them are dust, water-vapour, and carbonic acid gas.

The Dust in the Air.—There are immense numbers of tiny solid particles in the air, but they are so small that they are usually invisible. Sometimes indeed there are so many that we can see them, and we say "the air is full of dust." But even in what seems to be the clearest and purest air, there are millions of particles of dust. They may sometimes be seen if a beam of sunshine shoots across a dark room through a hole in the shutter. Where does all this dust come from?

It comes from the earth and it comes from the sky. As the soil crumbles away, the finer dust is carried upward by currents of air and spread all over the earth and the sea, so that the air is full of it. Immense quantities are ejected by volcanoes. And dust comes also from the "shooting stars" or *meteorites* in the sky. They fall on the earth in great numbers by day and by night, though we can only see such as fall by night. These meteorites are pieces of rock of all sizes, scattered in vast numbers through space, and may be perhaps fragments of a planet that has burst into pieces. They speed along in a wide band through space, but when they come within the pull of the earth's attraction they rush into our atmosphere. There the friction or resistance of the air breaks them up into fine dust.

They get white-hot and appear to us as a tail of light that fades as soon as it is seen. It is believed that not less than 20 millions of these meteorites reach the air every day. Their dust is called *cosmic* or world-dust, to distinguish it from earth-dust.

The dust in the air over the sea settles down upon the water, sinks slowly through it, and at last reaches the bottom as sediment, and is pressed into solid rock. It is the dust in the air which gives the sky its blue and its brilliant tints at sunrise and sunset, by reflecting and softening the sunlight which shines through it. Without it the sky would look black and the stars would be seen by day as well as by night. It causes the twilight in northern latitudes, by reflecting the light of the sun in front of it before it rises and behind it after it has set. The farther we go to the north or to the south, the longer the twilight. In these latitudes, *e.g.* in England, it is quite light in the morning long before sunrise and in the evening long after the sun has set. Fig. 57, in which the atmosphere is represented by the light shading all round the earth, shows that the rays of the sun, the "slanting rays" as they are called, have a much greater thickness of air to travel through at sunrise and at sunset than the direct rays at noon. This is why we can look at the sun for some time after it has risen and for some time before it sets, without blinking, while at noon the bright rays dazzle our eyes. Fig. 57 shows also the greater thickness of the air which the slanting rays have to pierce in northern and southern latitudes than the direct rays which fall on the earth within the Tropics.

Without the dust in the air there would be no rain, no mists or clouds or snow or dew. All these forms of water are made by the condensing of the water-vapour in the air upon the invisible particles of dust.

Carbonic Acid Gas is a combination of the two elements carbon and oxygen. Carbon is a solid of which there is a great deal everywhere. Coal is nearly pure carbon, and so is black-lead. A large part of the bodies of animals and of the substance of plants is carbon. When they burn or decay, and when animals breathe, the carbon in them unites with the oxygen in the air to form carbonic acid gas. When a fire burns, the black smoke that rises into the air and mixes with it is carbon dust. The carbon in carbonic acid gas is the food of all plants. They take it in from the air through their leaves in sunlight and it becomes a part of them. When they die or decay the carbon passes into the air again. In this way carbon is always passing in and out of plants and animals. Without it they could not live. The quantity in the air is small compared with the air itself, being only about 3 parts in every 10,000 parts of air. Yet it is enough to support the grass, the crops, the plants, and all the vast forests of the world.

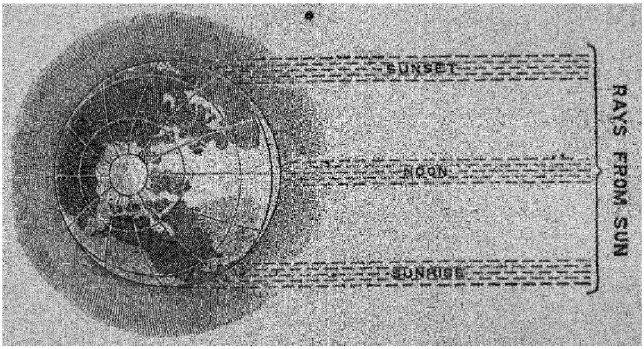


FIG. 57.—RAYS OF THE SUN THROUGH THE ATMOSPHERE.

Water-vapour is water in the state of a gas. Whenever water is heated, steam or water-vapour rises from it into the air. We cannot see it, but it is always rising and the air is full of it. As the sun shines on the ocean, on rivers and on lakes, water is always "evaporating," *i.e.* rising into the air as vapour. It rises because it is lighter than air.

The carbonic acid gas and water-vapour in the air keep the earth warm, as a blanket keeps a man's body warm. The rays of the sun heat the air as they pass through it, but they heat the ground much more. Not more than about one-third of the heat is absorbed by the air as the downward rays pass through it. The heat which reaches the ground is radiated back by the ground into the lower layers of the air resting on it, and this heat is much greater than the heat they received from the downward rays. Carbonic acid gas and water-vapour are both bad "conductors" of heat. Heat does not pass through them easily. They keep back the heat of the earth just as glass does. In a green-house or glass-house in which plants are put to keep them warm, the air is much warmer than it is outside. The bright hot rays of the sun pass through the glass and heat the plants and the floor inside, but the glass keeps back the rays of heat and prevents them from escaping into the air. If there were one-third less carbonic acid gas than there now is in the air, the earth would be covered with ice, for its heat would escape into the upper regions of the air.[1] The clouds and the water-vapour in the air help to keep the earth warm too. The air on a cloudy night is often much warmer than it is on a bright clear night. The blanket of cloud keeps in the heat.

EXERCISES.

1. What elements make up the air, and in what proportions?
2. Where does the dust in the air come from? Explain the term "cosmic dust."
3. Of what use is the dust in the air? How does it contribute to the beauty of scenery?
4. How does the air feed—(*a*) animals, (*b*) plants?
5. How does the air keep us warm?

18. THE ATMOSPHERE (*continued*).

PRESSURE OF THE AIR.

Weight of the Air.—We cannot see the air, nor do we feel it except when it moves. We do not think of it as heavy. We say "as light as air." All gases are light compared with liquids or solids. Yet the air has weight. It has been weighed. *At the sea-level* 13 cubic feet of air weigh one pound.

How high the atmosphere is we do not exactly know, but there are reasons for thinking that the air rises upwards to a height of from 100 to 200 miles. It is not, however, equally dense the whole way up. The upper air presses down the lower air, so that it is densest close to the earth. The higher the air the lighter it is.

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[1] *Physiography*, by Huxley and Gregory, 1912, p. 88.

The weight or pressure of the whole atmosphere at the sea-level is 15 lbs. on every square inch of surface under it. It presses downwards with this weight. But the air is a *fluid*,[1] and like all fluids it presses equally in all directions—upwards, downwards, and sideways. This is why we do not feel it pressing upon our bodies. Our bodies, too, are full of air, and this air presses outwards against the air pressing inwards, so that we do not feel it.

The Mercurial Barometer.—The weight or pressure of the air is measured by the *Barometer*,[2] in which air is weighed against mercury. The common barometer is a glass tube about 33 inches high, closed at one end so that no air can get in, and open at the other. It is filled with mercury, on which the air presses at the open end. Here we have two columns, one of air and the other of mercury. The column of air, a very light gas, is invisible, but we know that it goes right up to the upper limit of the atmosphere, say 100 miles high. On the other hand the column of mercury, which is a very heavy liquid, is less than 3 feet high. The two columns balance one another, as two equal weights do in a pair of scales. At the level of the sea, it is found that the air presses on the surface of the mercury at the open end with force enough to hold up the mercury in the tube at the height of 30 inches. If it were not for the weight of the column of air the mercury would, of course, run out of the tube. But the air presses the mercury downwards, and the mercury at the open end "communicates," or passes on, this pressure upwards to the column in the tube and thus keeps it up 30 inches.

You must notice that this is the pressure of the air in ordinary weather *at the level of the sea*, where the atmosphere is highest and its full weight is felt. If you take the barometer up a hill or in a balloon, there is less air above it, and the mercury in the tube will fall lower, because the pressure of the air is less than it was at the sea-level. The barometer, therefore, shows us the height of any place, where it stands, and the pressure of the air at that place. If the air be dense and heavy the pressure is said to be *high*. The mercury keeps high in the tube. If the mercury falls, it shows us that, for some reason or other, the air above it has become lighter and rarer; the pressure is then said to be *low*.

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[1] *Fluid*, from the Latin *fluo*, flow. The term fluid includes liquids, gases, and vapours, for the particles of all three flow freely over one another, while the particles of solids do not move.

[2] *Baro-meter*, from the Greek *baros*, weight, and *metron*, a measure. It is so called because it measures the weight of the air.

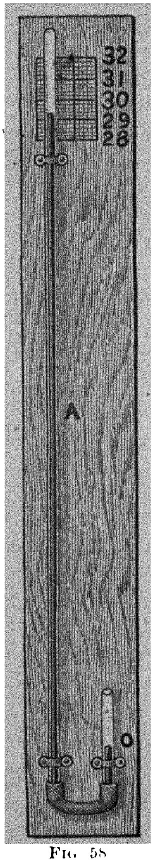

FIG. 58
MERCURIAL BAROMETER

The barometer is only 33 inches in height, because the mercury can never rise up to that height. Why do we use mercury? Because mercury is heavy and we need only have a barometer of this height, 33 inches. We might weigh the air against water, but a barometer of this sort would be 34 feet high, for water is about $13\frac{1}{2}$ times less dense than mercury, and a barometer of this size would be inconvenient to use.

The rate at which the mercury falls is, roughly, about 1 inch for every 900 feet as we ascend. Mont Blanc, the highest peak in the Alps, is about 3 miles high. There the barometer falls to about 15 inches from 30 at the sea-level. The pressure of the atmosphere, *i.e.* the weight of the air, is about one-half what it was at sea-level, and the density is also about one-half, *i.e.* a cubic foot of air, which at the sea-level weighs $1\frac{1}{4}$ ounces, weighs only $\frac{5}{8}$ of an ounce at the top of Mont Blanc.

One-half of the whole mass of the air lies below the height of $3\frac{1}{2}$ miles, *i.e.* about 18,500 feet. Another rise of $3\frac{1}{2}$ miles to 7 miles leaves half of this half, *i.e.* three-quarters of the whole below and one-quarter above. The weight of this is equal to $7\frac{1}{2}$ inches of mercury. At the height of 21 miles the mercury in a barometer would stand at 1 inch high.

TEMPERATURE.

Temperature.—The temperature of the air has a good deal to do with climate, for it is the main cause of the winds which make lands warm or cold by blowing over them, and of the rain which the winds bring with them. The term "temperature" means state or condition of hotness or coldness. Hot air is said to be at a high temperature and cold air at a low temperature.

How Temperature is measured.—The temperature of the air is measured by the *Thermometer*, which shows how hot or how cold the air all round it is. In the thermometer mercury is used, as well as in the barometer. In the latter, the rise or fall of the mercury shows us the pressure of the air; in the former, the rise or fall of the mercury, as it expands or contracts, shows us the temperature of the air. All bodies, we know, expand or grow larger as they are heated, and contract or grow smaller as they cool, whether they be solid, liquid, or gaseous. Mercury, being a liquid, expands and contracts easily, and this is one reason why it is used.

Thermometers.—To enable us to see the changes in temperature marked by the rise or fall of the mercury, a "scale" of figures is marked on the side of the glass tube. In Fig. 59 we see three kinds of thermometers. They are all alike except in the scale.

The thermometer is a tube of thick glass called the *stem*, opening downwards into a ball of very thin glass called the *bulb*. No air can get inside, as the top end is sealed. There is nothing inside but mercury. The heat of the air outside goes through the thin glass of the bulb and heats the mercury in it. As the mercury gets hot, it rises in the tube, and may be seen through the glass, rising in the stem. If the air cools, the mercury inside the stem also cools and falls.

The thermometer in the middle is the one usually used in England because it was the only one known for a long time. It is called the *Fahrenheit*, after the man who invented it. In it the temperature at which water freezes, or, which is the same thing, the melting-point of ice, is marked 32°. The temperature at which water boils is marked 212°. The space between the two is divided into 180 degrees (not shown in the Figure in the book). The *Centigrade* or hundred-degrees thermometer is also used in England by men of science. In it the melting-point of ice is marked 0° and the boiling-point of water is marked 100°. The *Réaumur* thermometer is used in Germany and Russia. In it the boiling-point of water is marked 80°.

The figures marked on the scale of a thermometer are used to describe the temperature of the air anywhere. If we want to describe the temperature, or, in other words, to say how hot it is, in Calcutta, or Bombay, or Madras, on any day, we do so by saying the temperature is 90°, or 80°, or 60°, as the case may be. Any one in any part of the world will know what this means exactly. So if you should read that the temperature in London on some day in winter was 32°, you know exactly how cold it was on that day.

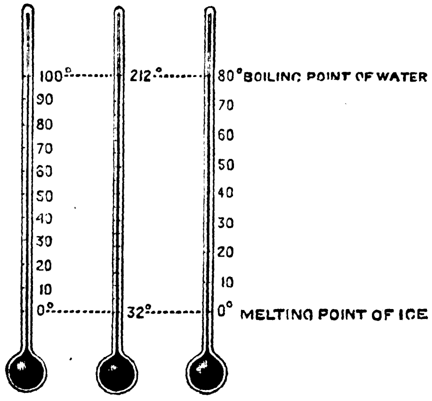

FIG. 59.—THERMOMETERS.

How Changes in Temperature are caused.—The air and the earth are heated in three ways—by radiation, conduction, and convection.

Radiation.—The sun is the source of all the heat in the air. Its bright hot rays heat the air as they come down through it, and heat the air again, a second time, as they are radiated back into it from the earth as dark hot rays. These dark rays heat the air much more than the bright rays. The direct rays of the sun heat the air and the earth more than the oblique or slanting rays, as we saw in Lesson 6. The zones of sun-heat, in Fig. 16, show that the temperature is highest (at the sea-level) in the Tropics, and lowest in the Polar regions. *Temperature depends*, therefore, in the first place and mainly, *on latitude.*

Conduction.—Heat passes from one body to another when the bodies do not move, but touch each other. Solids are better conductors of heat than liquids, for their particles are closer to one another, and liquids are better conductors than gases, whose particles are still farther apart. The denser a body is the more easily heat passes through it. For this reason land is a better conductor of heat than water. It heats more quickly and cools more quickly. Heat passes into it and out of it rapidly.

The surface of the land when heated by the sun warms the layer of air resting on it by conduction. That heat is spread through the upper layers by convection.

Convection.—The lower layer of air resting on the earth when heated expands, becomes lighter than the air above it, and rises through it. The upper layers, being colder and heavier, sink down to the ground, and are heated, and rise in their turn. There is thus an upward current of air and the whole mass of air is warmed. This passing upwards and downwards of the air is termed "convection."

Liquids are heated in the same way. When water is heated from *beneath*, *e.g.* when it is boiled in a pot over a fire, the lower layer is heated first and rises, and the colder and heavier upper layer of water sinks through it to the bottom, is heated and rises in its turn, till all the water in the vessel is heated. This is convection. (See pp. 110-111.)

But when water is heated from *above*, *e.g.* as the water in the sea is heated by the rays of the sun, the upper layer, being warm, cannot sink, for it is lighter than the colder layers under it. It does not move, neither do the lower layers move. But the heat passes slowly from the upper layer to the lower by conduction.

Heat, it is clear, cannot pass by convection through a solid body like land, for its particles are fixed and cannot go up and down when heated as those of air and water do. There are currents of air and currents of water, but there are no currents of land. The sea heats very slowly under the sun's rays, and cools just as slowly. The land heats rapidly, and cools rapidly. The unequal heating and cooling of the land and sea is the cause of the winds, as we shall see.

EXERCISES.

1. How do we know that the air has weight? What does it weigh?
2. Why do we not feel the weight of the air upon us?
3. Describe the barometer; how it is made; its use.
4. Why is mercury used in a barometer, rather than water or any other liquid?
5. How does a barometer show the height of a mountain?
6. How does the air affect climate?
7. How can we tell how hot or cold the air is in any place?
8. Describe how a thermometer is made.
9. What is the difference in marking the scale, on—(*a*) a Centigrade, (*b*) a Fahrenheit, (*c*) a Réaumur, thermometer? Why is each of these instruments so called?
10. The air and the earth are heated in three ways—by radiation, conduction, and convection. Describe each of these ways, with examples.

19. ISOTHERMS.

HEAT EQUATOR.

THE zones of sun-light and sun-heat in Fig. 16 divide the surface of the earth into broad spaces, according to the temperature of the layer of air close to the surface, due to the heat of the sun's rays as they strike it. The direct rays are hotter than the oblique or slanting rays, and therefore the temperature of the air in the Tropics is higher than that in the Temperate zones, and the temperature in these zones is higher than that in the Frigid zones.

It is the temperature of the air above a place that makes it feel hot or cold. If this temperature were due only to the bright rays as they reach it from the sun, then the latitude of a place would give us its temperature. We should know at once that a place 10° north of the Equator would be hotter than another place 15° north, and so on. But most of the heat in the air is not due to these bright rays, but to dark heat rays which are radiated back into it from the surface of the earth. This heat varies according to the nature of the surface. If it were all sea, or all land on one level, and if the land were all rock of one kind, covered with soil of the same sort, then, indeed, the radiation would be the same everywhere and the heat would vary exactly with latitude. But three-quarters of the surface of the earth is sea and one-quarter land, and the land lies on different levels. It may be a high plateau or a low-lying plain, it may include lofty mountains or low hills, it may be covered with green grass or thick forests, or it may be a dry and sandy desert.

Also the rocky crust of the earth which makes up the surface of the land, either in solid blocks or crumbled into soil, is made up of many different kinds of rock which absorb and radiate heat differently, some of them being better conductors of heat than others. And land absorbs and radiates heat much faster than water does.

We must remember, too, that even the heat of the bright rays of the sun is not always greatest at that part of the surface of the earth directly under the Equator. As we saw in Lesson 6, the line of greatest heat keeps changing as the earth moves in its orbit round the sun. It is sometimes north of the Equator and sometimes south of it. Like a parallel of latitude, it is an imaginary line going right round the earth, and it changes every hour and every moment, moving northwards as the North Pole of the axis of the earth inclines towards the sun, and southwards as the South Pole inclines towards the sun. It follows the "swing" of the axis of the earth, or, as it appears to us who are on the earth, the "swing of the sun." With it the temperature marked by the Tropics and the Warm Temperate zones moves also north and south of the Equator. This line of heat is not the same as the Thermal Equator described later on in this lesson. It is fixed solely by the heat of the bright rays as they penetrate the air, while the Thermal Equator is fixed by the dark rays radiated by the earth into the air.

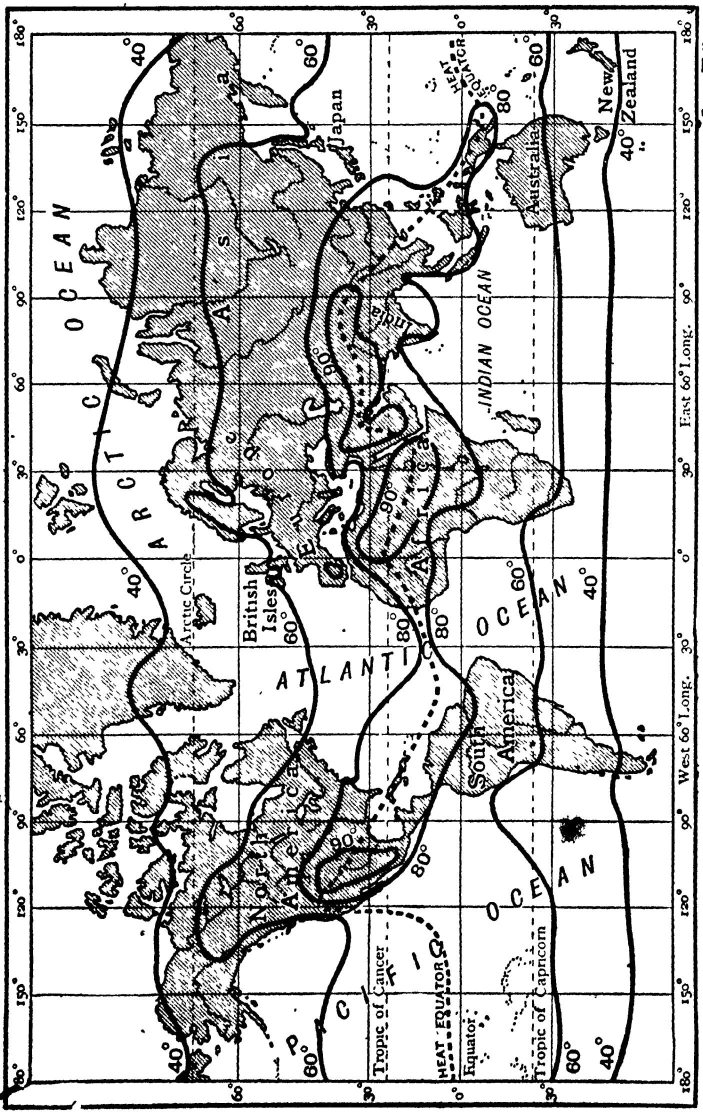

FIG. 60.—MEAN JULY ISOTHERMS OF THE WORLD.

In summer, in the northern hemisphere, the tropical heat moves northwards into the Warm Temperate zone, the warmth of this zone moves up into the Cool Temperate zone, the coolness from this zone takes the place of the cold zone above it, and the coldness of the Frigid zone lessens as the Arctic Circle comes within the rays of the sun.

As, in summer, warmth moves upwards, so in winter, in the same northern hemisphere, cold and coolness spread downwards. The coldness of the Frigid zone goes far southwards into the Temperate zone, and the coolness of this zone moves downwards into the warm zone, and in the Tropics it is warm rather than hot along its northern border.

The temperature of the air at any place does not depend altogether on its latitude. In other words, the temperature at two or more places having the same latitude is not always the same, even when they are at the level of the sea. For instance, London and Irkutsk (in Siberia) are both in very much the same latitude, viz. 50° N. Yet the mean annual temperature in London (by the thermometer) is 50°, while at Irkutsk it is 39°. New York and Lisbon and Pekin are all three in N. latitude 40°. But the temperature is 51° in New York, 53° in Pekin, and 60° in Lisbon.

These differences in temperature between places having the same latitude are explained clearly by *Isotherms.* What are isotherms?

In describing the "temperature" at any place we should notice three things, viz. the highest annual temperature, the lowest temperature, and (between these) the average or mean temperature, *i.e.* what the greatest heat in the year is, what the least heat is, and what the average heat is. The difference between the highest and lowest is called the *range* of the temperature.

If the temperature of the air for every hour of the day and night be registered, and the figures added together and divided by 24, we shall get the average or mean temperature for that day. If the mean daily temperatures for the whole year be added together and the total divided by 365, we shall get the *mean annual temperature.* This is done regularly in many stations all over the world.

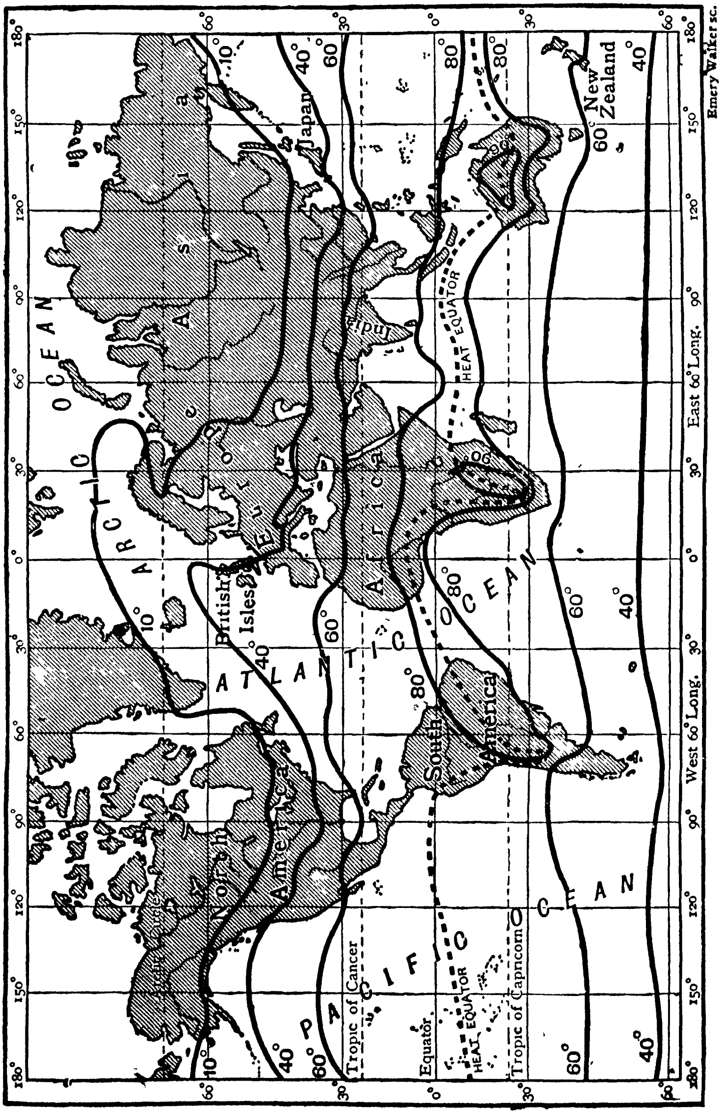

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FIG. 61.—MEAN JANUARY ISOTHERMS OF THE WORLD.

If, then, we draw a line on a map through the names of all places having the same mean annual temperature, we shall have a line of equal temperatures. A line like this is called an *Isotherm.*[1] But as a map like this would be very crowded with names, it is usual to omit the names and leave the lines only as is done in Figs. 60 and 61.

We know that temperature on land decreases with altitude; in other words, the air grows colder as we go higher. Therefore a true isotherm would go up and down, with many turns and twists, as it followed the heights. It would come down southwards on the map from a place in Iceland to any place high up on the Himalayas. It would be very difficult to read such a map. It is usual, therefore, to show upon isotherm maps the temperatures on land *at the sea-level* only. They are really temperatures for "imaginary flat countries without hills." Over the sea, isotherms show actual temperatures.

In other words, in these maps the actual temperature of a place is reduced to the sea-level temperature. We know that the temperature as tested by the thermometer falls about one degree for every 300 feet of height. **Quito** is a town on the Equator in South America. It is 9000 feet above the sea. This height gives it a temperature 30 degrees lower than it would have if it were at the sea-level. If the isotherm of 80° pass through it, we understand that its actual mean temperature is 80° - 30° = 50°.

The most important isotherms are those which show the mean annual temperatures for January and July, the coldest and the hottest months, for they give us the *range* between the highest and lowest temperatures. Fig. 61 is a map of the mean January isotherms of the world, and Fig. 60 a map of the mean July isotherms. The thick dotted line in the middle of both maps is the Thermal or Heat Equator. Fig. 62 is a map of the mean annual isotherms, and the dotted line in the middle is the mean annual Heat Equator.

These isotherms should be studied very carefully, because they show us very clearly how and why temperature changes. They show us why and when the air above any country is hot or cold. They help us, therefore, to understand what makes the climate of a country; for, as we shall see, climate depends very much upon the temperature of the air.

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[1] Greek *isos*, equal, *therme*, heat.

We see, for example, how *temperature changes with the seasons.* Look at the two maps in Figs. 60 and 61. Follow with your eye the highest isotherm on both maps. At all the places along this line the thermometer stands at 40° in July, *i.e.* in summer. But where is this 40° isotherm in the map for January, *i.e.* in winter? It is not where it was? Why not? Instead of it, we see an isotherm marked 10°. At all the places on this line the temperature has fallen at least from 40° in July to 10° in January, *i.e.* by 30°. But in many countries the temperature has fallen much lower than this. See where the summer or July isotherm of 40° runs in North America and in the great continent of Eurasia, including Europe and Asia. It is in the far north of these countries. Through the centre of the same countries runs another isotherm marked 80°. The temperature marked 10° on the isotherm in January has come down to the centre, *i.e.* it has fallen from 80° in many places in July to 10° in January, *i.e.* by about 70°. In all these places the air was very cold in January and very hot in July.

The isotherms also show us how *temperature depends on latitude.* At the same season of the year the temperature in high latitudes is always lower than it is in low latitudes. The farther north or south we go from the Heat Equator, the cooler the air gets, both in summer and in winter.

Again, we see that in *winter the temperature is higher over the sea than over the land.* Look at the January isotherms. Here it is winter in the northern hemisphere. The isotherms all rise over the sea, showing that it is warm there, and bend southwards over the land showing coldness. Follow isotherm 10°. It bends far to the south over the land in North America, but as soon as it comes to the Atlantic Ocean it runs up northwards and goes still more to the north in the Arctic Ocean, but again bends southwards over the land of Europe and Asia.

In summer the temperature is higher over the land than over the sea. Look at the July isotherms. Here it is summer in the northern hemisphere. The isotherms in that hemisphere now rise over the land, showing how hot the air is there. They bend southwards over the sea. Look at the isotherm 60°. It runs up northwards in North America and Eurasia, but sinks over the Pacific and Atlantic Oceans. The isotherm 40°, it is true, rises a little in the western part of the Arctic Ocean. This is due to the warm westerly winds which blow at this season of the year in that region.

We see, too, that places in the middle of the land, in the centre of the great continents, are very hot in summer and very cold in winter. The temperature is said to be continental. On the other hand, in places close to the sea, particularly in islands which are surrounded by the sea, the air is cool in summer and warm in winter; the temperature is maritime, *i.e.* like that of the sea.

The range of temperature, from heat to cold and from cold to heat, is shown very markedly by the isotherms. This range affects climate very much. A place where it is very hot at one time of the year and very cold at another time is not a pleasant place to live in. Over the sea the isotherms do not run up and down nearly so much as they do on land. We saw before that if the surface of the earth were all sea the temperature would be the same along the same line of latitude. Look now at isotherm 40° in both maps. It passes over scarcely any land and therefore it is almost a straight line like a parallel of latitude. It is a great contrast to the isotherms which pass partly over the sea and partly over the land, *e.g.* isotherm 60° in July and 10° in January.

And these isotherms show us one or two things more about the temperature of the air. There is a greater range from heat to cold and back again from cold to heat in the north Temperate zone than anywhere else. See how the isotherms in this zone run up and down with the seasons. This is because there is more land here than anywhere else. Between the Tropics, in the Torrid zone, there is no such violent change. It is always hot. Look at isotherm 60° in the map for January. It bends up and down very little. On the whole, too, there is less change in

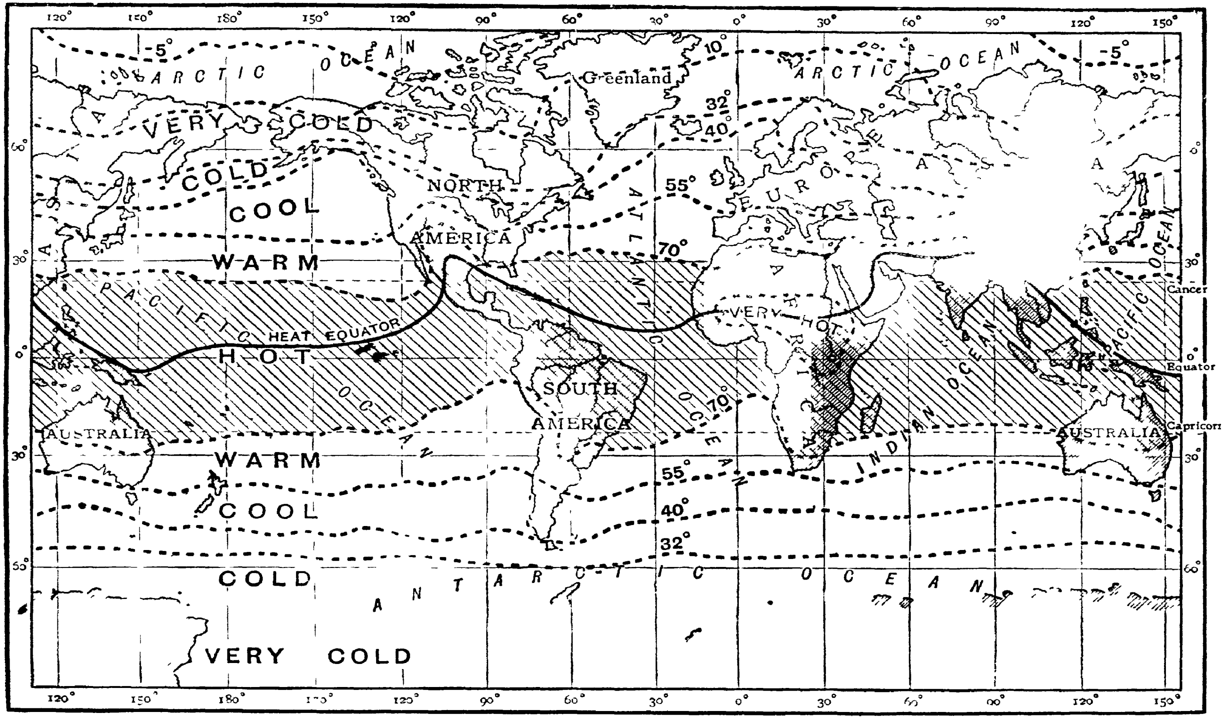

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FIG. 62.—MEAN ANNUAL ISOTHERMS AND HEAT EQUATOR

the southern hemisphere than in the northern, because it has more sea than land.

The Thermal or *Heat Equator* is shown by the thick dotted line in the middle of each of the three maps. It is a line drawn through the places above which the heat of the air is greatest; in other words, through the hottest places within the Tropics. The heat is the heat radiated into the air by the hot dark rays from the earth. The heat above this line is much greater than that of the line of heat, described in Lesson 6, which marks the greatest heat from the bright rays. The Thermal Equator moves up and down as the isotherms do, although it is not itself an isotherm.

EXERCISES.

1. How does the alternation of land and water affect the heat of air?
2. Describe the "line of greatest heat," and its constant movement. How does this line differ from the equator?
3. How does the heat of the zones change during the year?
4. Give some instances of places in the same latitude having a different mean annual temperature, and account for the differences.
5. What is an isotherm? Why is it so called? Of what use is it?
6. How does an isotherm over the land differ from one over the sea?
7. How is it that the isotherm of 80° passes over Quito, the actual temperature at that town being only 50°?

20. CLOUDS, FROST, AND SNOW.

THE WATER IN THE AIR.

WATER is a liquid, but when it is heated it becomes a gas which is called water-vapour. The vapour which rises from boiling water is steam. Steam, when it is pure and not condensed, is invisible. We cannot see steam or water-vapour any more than we can see air. But when the vapour rises into the air, some of it condenses when it touches the invisible dust in the air, and then we can see it. A speck of earth-dust, however tiny, is a solid, and is colder than a particle of water-vapour. When the latter touches the former it becomes cold too, and condenses, or rests on it as a liquid. The condensed vapour takes different forms and shapes, known as cloud, mist, and fog. When still further condensed it becomes liquid, and even solid, and falls back on the earth as rain, hail, and snow.

Clouds.—So long as the rising vapour is close to the heated ground, we cannot see it. But as it rises higher into the cooler air it condenses, and is seen in the shape of clouds. A cloud is held up by the air underneath it. It may seem strange that a cloud can float in the air. If you hold a small book in your hand, and let it go, it will fall at once to the ground. Tear out all the pages and let them go separately. Each of them will fall to the ground, but very slowly. Tear a page into tiny bits and let them go. These bits of paper will flutter about and fall still more slowly. The air holds them up. If you could tear each bit ~~of paper~~ into a million of tiny particles, so fine that you could not even see them, they would not fall for a very long time. They would float ~~about~~ in the air. So it is with the water-dust in the air.

Rain.—The hotter the air the higher it rises, carrying up the water-vapour in it. The air is never still. The water-vapour in it is carried about with it. It rises high above the earth whenever it is over a heated part of the surface. As it reaches the cooler upper currents of air, it condenses a little and a cloud is seen. The cloud may meet with a colder current of air. It is chilled, and condenses still more into drops; the cloud becomes darker and darker as the drops get larger. At length they are so large that the air cannot hold them any longer, and they fall to the earth as *rain*. The whiter a cloud is, the colder the air is in which it is floating. The very white clouds, far up in the sky, are made of ice-dust, for the air up there is cold enough to freeze water, and must be below the temperature of 32°.

Mist and Fog.—The ground is often very cold late at night or early in the morning, when it has radiated most of its heat into the air. If there be much water-vapour in the air above the cold surface, it condenses over the ground and is called *Mist* or *Fog*. A mist is a light fog, and both mist and fog are merely clouds resting on the cold ground. A cloud is a fog high up in the air. Mountains and hills are often covered with mist, for currents of warm air rushing up their slopes are chilled when they reach the colder air always found on the heights of mountains. Thick yellow or brown fogs are often seen in large towns like London and Calcutta. The dirty colour is due to clouds of smoke which fill the air from the factory chimneys. Heavy fogs sometimes rise over large rivers or over the sea. On the Brahmaputra the fog is often so thick that river-steamers have to stop for hours. Off the coast of Newfoundland in North America there are banks in the sea dreaded by sailors because of the thick heavy fogs which hang over them and hide from view the icebergs which come down from the north. Many ships and steamers have been wrecked here. The fogs are caused by the meeting of a current of warm water called the Gulf Stream and a current of cold water known as the Labrador Current. Over the warm current the air is full of warm vapour. It is chilled when it meets the cold air over the cold current, and condenses into fog.

Dew and Frost.—At night, if the sky should be clear and free from clouds, which, as we saw in Lesson 48, keep in the heat of the earth like a blanket, the ground, and the grass upon it, give off into the air the heat which they took in while the sun was shining, and get cold. By morning the air above the grass gets cold also and contracts. When it does this it cannot hold so much water-vapour as it did before; the moisture is squeezed out and deposited on the grass in drops of water, which is *Dew*. The warmer the air is the more vapour it can hold; the colder it is, the less it can hold, for the particles come closer together. When, at any temperature, it can hold no more vapour, the air is said to be *saturated* or full. If it be cooled below this point dew is deposited. The highest temperature at which dew forms is called *Dew-point.* Sometimes when the temperature is below 32° in the air close to the ground, the dew is deposited in a solid form as frozen vapour, and is called *Frost* or *Hoar-frost*, *i.e.* White frost.

Ice is water in a solid state. Water freezes or changes into ice at the temperature of 32°, which is called the freezing-point.

Nearly every liquid becomes smaller in bulk, or volume, or size, when it changes into a solid. But water and one or two other liquids actually occupy more space as solids than liquids, so that the solid weighs less than the liquid. This may be seen by putting a piece of ice into water in which it does not sink but floats. Ice weighs about nine-tenths of an equal volume of water. It floats in fresh water, with about one-tenth of its bulk above the water. *Icebergs* are huge masses of ice, often hundreds of feet high, which are formed in the Polar seas, where the temperature is always far below 32°. They float down to lower latitudes, chilling the air above them.

Hail and Sleet.—Rain falling in drops from a great height is often frozen, as it falls, by passing through a very cold layer of air. The frozen drops are called *Hailstones*. They are much larger and heavier than the ice-dust of snow. *Sleet* is half-melted snow which has fallen through a warm layer of air.

Snow.—In the higher regions of the air, where it is intensely cold, the water-vapour is frozen into tiny pieces of ice. They are much smaller than drops of rain, so small that they may be called ice-dust. This is *Snow*. It falls to the earth and covers the ground like a white sheet. In hot countries the snow is changed into rain as it falls through the lower layers of warm air, but in cold countries it keeps its form and falls softly and noiselessly to the earth, looking like white feathers, called snow-flakes, floating down from the sky. It may fall for hours or even days together and lie in a sheet many feet thick.

Snow-Line.—There is a height in the air, whether over land or sea, at which the temperature falls to 32° and never rises above it. Above this height snow and ice never melt. The height varies according to latitude, for the air gets colder and colder as we go from the Equator towards the Poles. It varies according to the season of the year, for in the same latitude the air is colder in winter than in summer. On land also it varies according to the height of the land, for the air is colder on hills and mountains than at the sea-level, although the latitude may be the same. A line drawn through the air, over land and sea, marking the limit above which water-vapour must condense into ice, and below which it condenses into water, would be a *snow-line*. In Fig. 63 the height of the snow-line on various mountains from the North Polar sea to Equatorial Africa is shown. The Alps rise through the snow-line at about 9000 feet. Above this height there is perpetual snow on the Alps. On the great volcanic mount of Kilimanjaro in East Africa the snow-line runs at 16,000 feet. The Himalayas stand in one of the hottest regions of the earth, but they are so lofty that their summits are covered with snow that never melts. On the north side of this lofty range, which lies open to the hot dry air from the heated plateau of Tibet, the snow-line is about 16,600 feet high, but on the south or Indian side the line descends 4000 feet lower. In the Andes of Peru the snow-line is at about 15,500 feet.

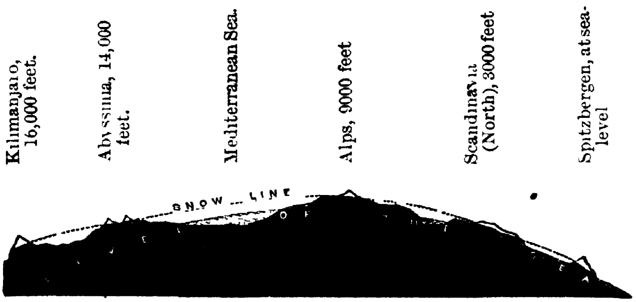

Kilimanjaro, 16,000 feet.
Abyssinia, 14,000 feet.
Mediterranean Sea.
Alps, 9000 feet
Scandinavia (North), 3000 feet
Spitzbergen, at sea-level
SNOW LINE

FIG. 63.—POSITION AND HEIGHT OF THE SNOW LINE BETWEEN EQUATORIAL AFRICA AND THE NORTH POLAR SEAS

It will be seen that in Fig. 63 the height of the dotted snow-line rises higher and higher from the sea-level at Spitzbergen, an island in the Arctic Circle, to 16,000 feet on Kilimanjaro in the Tropics. It is like a mighty invisible arch through the air, the highest central point rising to the height of some 18,000 feet at the Equator, while the two ends of the arch come down to the ground at the Arctic and Antarctic Circles. A half of this arch is shown in Fig. 64. It is the same curved line that is seen in Fig. 63, but it is shown in a different way.

We must be careful to distinguish between the *snow-line* and the *freezing-point* of water. Above the snow-line there is *perpetual* snow. But the freezing-point — *i.e.* the temperature at which water freezes—is higher or lower up in the air, according to the season. In England, *e.g.*, this point in winter is often at the surface of the ground, and then the ponds and streams have a crust of ice on their surface and one can walk over them dry foot. There is a frost. But in summer this freezing-point is a mile and a half overhead at the snow-line.

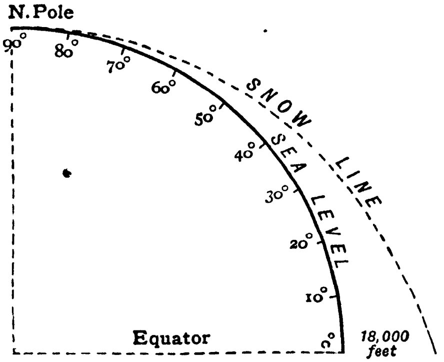


Fig. 64.
The Snow-line in different Latitudes.

Exercises.

1. Describe the formation of clouds, pointing out the part played by dust.
2. What is rain? What makes rain fall?
3. Describe the formation of each of the following forms of water: Mist, fog, hail, sleet, dew, snow, frost, ice, iceberg.
4. The great ocean steamer *Titanic* was wrecked off the coast of Newfoundland on April 14, 1912. Can you account for the wreck?
5. What is "dew-point"?
6. What is the snow-line? How and why does it vary in different parts of the earth? Give examples. Distinguish between snow-line and freezing-point.

21. RAINFALL OF THE WORLD.

Rain, as we have seen, is condensed from the water-vapour in the air, and falls, by its weight, on the surface of the land and the sea. As it falls through the air it cleans and purifies it, washing out of it all dirt and dust. Every one has noticed how fresh and pleasant the air feels after a shower of rain.

In describing the climate of a place, we must always think of the rainfall. That is what makes climate moist or wet or dry, and renders soil fertile. How are we to compare the rainfall of one country with that of another? How is rainfall gauged or measured?

The Rain-gauge.—Rainfall is measured by a rain-gauge. It is a round metal funnel for catching the rain, usually 8 inches in diameter at the top, and it is placed inside another vessel to store the rain and prevent loss by evaporation. Close to it, in Fig. 65, there is also a glass measure, marked in inches on the side, into which the rain is poured. The gauge is placed in the open air so that rain may fall freely into it.

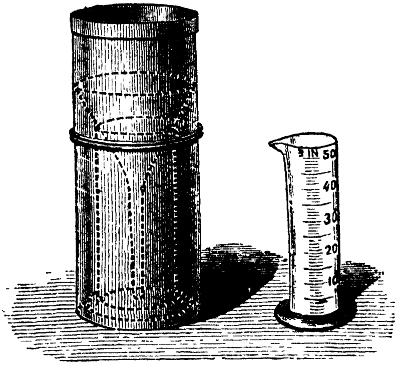


FIG. 65.—RAIN-GAUGE.

Once in 24 hours the rain that has fallen is measured and the amount put down on a register with the date. The rainfall for each month is found by adding up the daily totals, and the yearly rainfall by adding up the monthly totals. When we say that, within a certain time, an inch of rain has fallen anywhere, we mean that if all the rain that fell had remained on the ground without sinking into it, the ground would have been covered by water to the depth of 1 inch. If the rainfall for the whole year be 100 inches, we mean that the ground would have been covered by a sheet of water 8 feet 4 inches in depth.

As more rain often falls in one year than in another, it is usual, in describing the rainfall anywhere, to name the *average* rainfall of several years, say fifty. And in describing the rainfall over a whole country, we take the rainfall of a good many stations all over the country, divide the total by the number of stations taken, and then put down the *mean* annual rainfall.

The coloured Map 1 gives the mean annual *rainfall* of the world. The rainfall is marked in colours, as shown in the scale in the map. The countries marked in light yellow, as having less than 10 inches of rainfall, are all of them *deserts*; the *hot* deserts of the world lie in the Tropics or close to them, and the *cold* deserts in the Arctic regions. The amount of rainfall in each region of rainfall is given in figures. Thus the mean annual rainfall on the Himalayas is *above* 75 inches.

The heaviest rainfall is in the Tropics, the hottest part of the world, where the great heat causes enormous evaporation. This, indeed, is known as the "zone of constant rain." The rainfall decreases gradually northwards and southwards as the temperature of the air decreases towards the Poles. This is the general rule, but this rule is changed in many places by the arrangement of land and sea and by the winds.

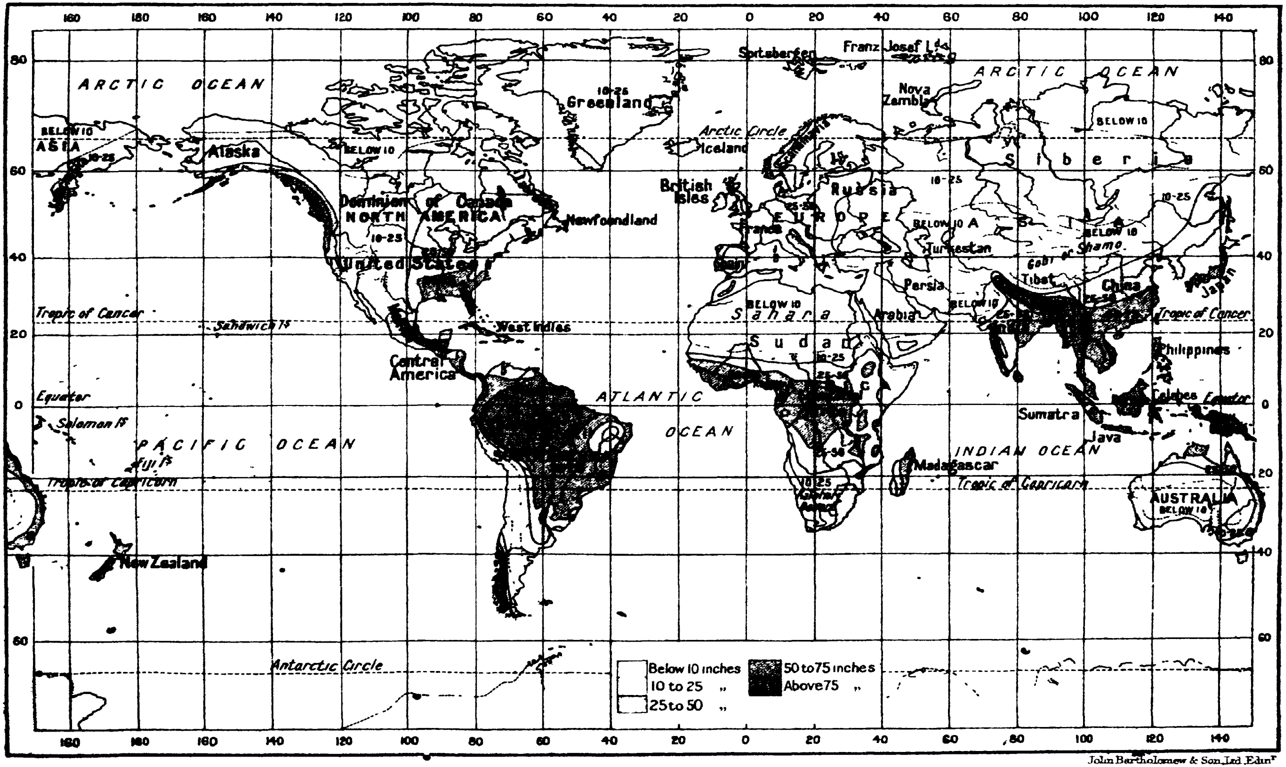
There is more evaporation over the sea than over the land, because of the greater extent of water. On the other hand, as the air is colder at night over the land, condensation is more active there. For this reason there is a heavier fall of rain over the land than over the sea, and there is, on the whole, a greater fall of rain in the northern hemisphere than in the southern, because there is more land in that hemisphere.

The condensation of vapour and the fall of rain is heaviest near the coast-line of a country washed by the ocean. In many countries, *e.g.* in the Deccan in India, the west coast is very rainy, while the interior is very dry. The clouds brought by the westerly winds rush up the slopes of the Western Ghats into the cool air on the summits of the Ghats. There the rain falls, and very little is left for the land on the other side of these mountains. In the British Isles the rainfall is heaviest along the western coast. When the prevailing wind is easterly the east coast gets the rain, *e.g.* in S.E. Africa.

A mountainous country has a heavier rainfall than one in the plains. This is because the air is cold and condenses the vapour that passes over it into rain.

Lands lying in the interior of a continent, far from the ocean, have, as a rule, very little rain. There is a great rainless tract of deserts that stretches from North Africa, where it is known as the Sahara, across Arabia, Persia, Baluchistan, far into Central

MEAN ANNUAL RAINFALL



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Asia, where it is called the Gobi or Shamo. In this arid tract the soil is dry and sandy. It becomes intensely hot under the blazing sun. The hot dry air rises, but the winds which blow in to take its place cannot deposit rain, even if there be moisture in them, for instead of being cooled they are driven upwards in the rising stream of hot air.

If we compare Map 1, showing the rainfall all over the world, with Map 2, showing the density of the population in the various countries of the world, we shall see that population depends largely on rainfall. Where the rainfall is abundant, and especially where it is moderate, there many people live, for there crops grow well. In a well-watered country the rivers which flow over the land and fertilise the soil are fed by the rainfall on the hills. On the other hand, where the rainfall is excessive and the land intensely hot, the country is unhealthy and few people live in it.

EXERCISES.

1. Describe a rain-gauge. In what ways is it useful?
2. What is meant by mean annual rainfall?
3. What and where is the zone of constant rain?
4. Why is there a heavier rainfall over the land than over the sea?
5. Why is there a heavier rainfall on the west coast than on the east coast of—(*a*) England, (*b*) India. Name a country in which the rainfall is heaviest on the east coast, and account for this.
6. What countries have little or no rain? and why?
7. Show by examples how the density of population varies with rainfall.

22. MOVEMENTS OF THE AIR.

THE air is never at rest. It is always in motion, rising or falling, or moving across from land to sea or from sea to land. It is, like water, a fluid; and, like water, it is always moving. The air we cannot see, but water we can see, and it will help us to understand some of the movements of the air if we think of water.

If water be poured into a tub, it does not remain heaped up where it is poured in. It spreads all over the tub, and the surface always keeps at the same level. When a stream of water flows into a lake, the water in the lake is always rising, so as to keep the surface level. The ocean, too, does the same. Enormous quantities of water pour into it from countless rivers, and rain is always falling into it, yet the surface is always, more or less, at one level, which we term the sea-level.

The ocean of air above us behaves in somewhat the same way. If from any cause there is less air in any part of the atmosphere than in other parts, the air comes streaming into it from all sides to fill it up.

What causes these differences in the state of the atmosphere? Why should there ever be more air in one place than in another? Why should there be a higher column of air over one part of the earth's surface than over another?

We have already learned what causes these changes in previous lessons on the atmosphere, on temperature, and on the water-vapour or moisture in the air.

When water is heated from below it expands, becomes lighter than it was before, and rises, as in Fig. 66. There is a lamp burning below the vessel which is heating the water. The arrows pointing upwards show how the bottom layer of water is rising to the top. When it gets there it flows over on both sides and sinks to the bottom as the arrows pointing downwards show. Meanwhile another layer has taken its place and rises to the top after it. All liquids are heated in this way, *i.e.* by convection.

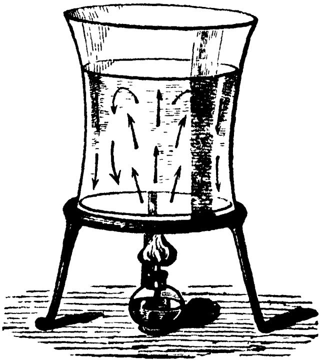


Fig. 66.—Heated Water rises.

Air behaves very much in this way. The land, heated by the rays of the sun, heats the air over it, as the lamp heats the water over it. The hot air expands, becomes lighter, and rises above the earth. As it does this the surrounding air rushes in to take its place, is heated, and rises too. Thus the column of air gets taller and taller. It is chilled when it rises very high and flows over on both sides *at the top of the column*, as the water does in Fig. 66.

That heated air rises may be seen by the smoke from any fire. We cannot see the air, but we can see the smoke which is carried up by the air. Smoke is merely coal or wood-dust. Why should it rise? A handful of coal-dust falls straight to the ground. It is the air, heated by the fire, that rises, taking the coal-dust, *i.e.* the smoke, with it.

Fig. 67 shows us how cold water sinks. There is a lump of ice, floating in the water, which chills the layer of water below it. It gets heavier than the water underneath and sinks to the bottom of the vessel as the arrows pointing downwards show. Here it gets a little warmer, and is pushed away by another cold layer sinking on it. It flows away on both sides *at the bottom of the upper cold layer*, and rises up the sides of the vessel. This chilling of the water by falling and rising currents is also termed convection.

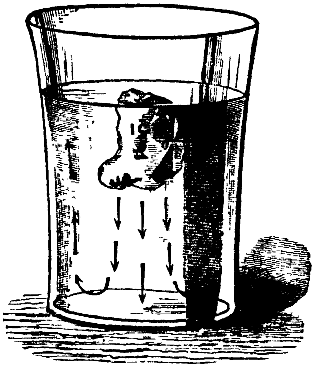


FIG. 67.—CHILLED WATER SINKS.

Very much in the same way air is chilled as it rises high above the earth by the coldness of the atmosphere above it. It then gets heavier and sinks to the earth, pushing away the lighter air beneath it, which flows out on all sides of the heavy cold column *along the surface of the earth*, and then rises, so as to make the surface of the whole volume of air, as far as possible, level.

Light air rises, heavy air sinks. And water-vapour, as we know, is much lighter than pure air. Air which is *saturated*, *i.e. full* of water-vapour, is, therefore, much lighter than dry air, and rises. Heated air, which has expanded, can hold much more moisture in it than cold air, for cold air is denser, its particles are closer together, and there is less room for the particles of vapour in it.

If we bear all this in mind, we shall understand how, and why, and when *winds* blow. Wind is merely moving air. Air moving at the rate of about 7 miles an hour is called a light breeze. If its velocity, or rate of movement, be 25 miles an hour, it is a strong wind. A gale of wind blows at the rate of 50 miles an hour, and the velocity of a hurricane or tornado is about 80 miles an hour. If rain comes down with it, we call it a storm or tempest; if there be thunder and lightning as well, it is a thunderstorm.

A column of cold dry air, being heavy, *presses* heavily upon the surface of the earth. This pressure is called *high* pressure. Hot or warm dry air such as there is above a desert of sand in the Tropics is much lighter, and if it be filled with the vapour of water, as it always is when it is over the sea, it is lighter still. The pressure of a column of this air is much less than that of a column of equal height of the former, and it is termed *low* pressure. In short, "high" pressure means heavy pressure and "low" pressure means light pressure. Of course a very low column of cold air does not weigh so much nor press so heavily on the earth as a very high column of hot air.

The great law of the winds is this: *Wind always blows from a region of high pressure to a region of low pressure.* It is always moving from a cold region to a warmer region.

The pressure of the air is always changing because the temperature is always changing; and, with these changes, the amount of moisture in the air is always changing too. This is why the wind so often changes. Some winds, however, are more or less *constant*, or permanent, others are *periodic*, or seasonal, *i.e.* they come at certain periods or seasons of the year; others, again, are variable or local. Different names were given to these winds by sailors in the old days when ships depended wholly on the wind.

Land and Sea-breezes.—Every one who has lived on or near the seaside in India has felt these light winds and knows them well. In the daytime, especially in the hot season, the land gradually warms up under the sun's rays, and, by the afternoon, the air over the land streams upwards as a current of hot air. The cooler air over the sea blows gently inward over the land to take the place of the ascending hot air. It is a *sea breeze.* Towards night it dies away, as the sun goes down, and the land cools. As the night wears away, the land rapidly radiates its heat into the air and becomes cooler than the sea, which has not parted with its heat so readily. Towards morning the air moves gently from over the cooler land to over the warmer sea. This is a *land breeze.* The clearer the air and the less cloud there is, the greater the radiation and the stronger the breeze is.

Let us now consider the great winds of the world. Look at the zones of sun heat in Fig. 16. Here we have a Hot zone at the Equator, then a Warm zone, then a Cool zone, and, lastly, a Cold zone. The air is cooler, and therefore denser and heavier, in each zone as we go northwards or southwards from the Equator.

In the Tropics, north and south of the Heat Equator, there is always a belt of heated air over land and sea. It is known (see Lesson 53) as the *Zone of Constant Rain.* Here a great current of hot air is always streaming upwards, carrying with it vast quantities of water-vapour, which rises from the heated seas.

As this stream of air and vapour reaches the upper region of the atmosphere, where it is very cold, the moisture condenses into rain and falls. This belt is a region of low pressure, for the air is saturated with water-vapour, which is very light. It is known as the *Belt of Equatorial Calms*, for the movement of the air is always *upward.* Very little wind blows *across* the land. The term "wind" is usually applied to horizontal currents of air over the surface of the land, not to vertical, *i.e.* upward or downward, currents.

As the air in this Hot zone rises and flows away to the north and south, far above the earth, towards the Poles, the cooler denser air of the Warm zones north and south of it creeps along the surface of the earth underneath it to take its place. There are thus two currents of air flowing in two opposite directions, one very high up, going towards the Poles, the other, below it, flowing towards the Equator. The lower current is called the *North-east Trade Wind* in the northern hemisphere, and the *South-east Trade Wind* in the southern hemisphere.

The upper current is cooled as it moves Poleward. It grows heavier, and a large part of it sinks to the earth just north of the Tropic of Cancer and south of the Tropic of Capricorn, replacing the air that streamed along the surface of the earth towards the Equator. There is therefore a great mass of moving air rising at the Equator, moving towards the Poles as an upper current, sinking to the ground at the Tropics of Cancer and Capricorn, and flowing back again to the Equator as a surface current. This is, on a very large scale, just like the convection currents of water that we saw in Figs. 66 and 67.

Winds are always named by the points of the compass *from* which they blow. Thus a north-east wind is one that blows from the N.E. (towards the S.W.), a south-east wind blows from the S.E. (towards the N.W.).

These winds were called *Trades* by the old sailors, because they were very steady and helped them in their navigation.

The trade winds would blow straight from the north and south towards the Equator, if it were not for the rotation of the earth. The earth, with the air resting on it, is spinning from west to east, with a velocity which is, at the Equator, over 1000 miles an hour. The velocity gets less and less towards the Poles, where it is *nil* (see Lesson 3). The rate at which the air is spinning eastward depends, therefore, on its latitude. In the northern hemisphere the wind which is streaming southwards towards the Equator, is acted on by two forces, and therefore it moves along the line which is known in physics as the *resultant* of the two forces, *i.e.* it moves in a line between them, just as the moon does in its orbit (see Lesson 7, Fig. 22). The pressure on it, acting alone, would make it a northerly wind, and the rotation of the earth acting alone would make it a westerly wind. It actually blows as a north-easterly wind. For as it blows southwards, its west to east velocity gets less and less than that of the solid earth beneath, because it blows from places where the velocity of rotation is less. It keeps this relatively slow velocity and seems to lag behind the earth in its rapid rotation westward. The effect of this is that as it nears the Equator it seems to blow from east to west, "just as a man travelling in a motor-car or aeroplane in the same direction as a wind blowing more slowly than he is moving, feels the air blowing in his face from the opposite direction." For exactly similar reasons, the wind blowing from the Tropic of Capricorn towards the Equator is a south-easterly wind. Forces like those just described act on all winds. For this reason there is scarcely ever a true northerly or southerly wind.

At the Poles, over the Arctic and Antarctic Oceans, there is a region of low pressure. This may seem strange, for the air there is intensely cold, and we know that cold air is heavy air. But although the air is cold there is not very much of it, that is to say, not so much as there is over other parts of the globe. The earth is spinning round with great velocity, and as we saw in Lesson 2 on the Rotation of the Earth, a globe of any material, solid or liquid or gas, will flatten at the Poles and bulge out in the middle if it be made to spin rapidly round on its axis. Fig. 6 shows that the diameter of the earth at the Poles is less than at the Equator. A gas bulges out still more than a solid, for its particles are not held together so tightly. The height of the atmosphere, therefore, at the Poles, is less than that elsewhere, more particularly at the Equator.

We have seen that a *part* of the great upward current of hot air at the Equator sinks to the earth in the warm zone. The rest of it passes onwards to the Poles as an upper current, mingling with the current of warm air rising from the warm zone. All this air is drawn towards the Poles by the low pressure there. The place of the warm air that rises from the warm zone is taken by cold surface currents that creep southward from the North Pole and northward from the South Pole. These cold currents from the Polar seas are turned partly to the east by the rotation of the earth, and are changed into north-east winds in the northern and into south-east winds in the southern hemisphere.

Also, between the warm and the cool belts, there are south-westerly winds which are converted by the different pressures over the masses of land and the sea in those latitudes into westerly winds. In the southern hemisphere these westerly winds are called by sailors the *Brave West Winds*. As they blow in about the latitude of 40° S. they also call them the *Roaring Forties*.

The main points to keep in mind, as regards these prevailing or constant winds of the world, are these:

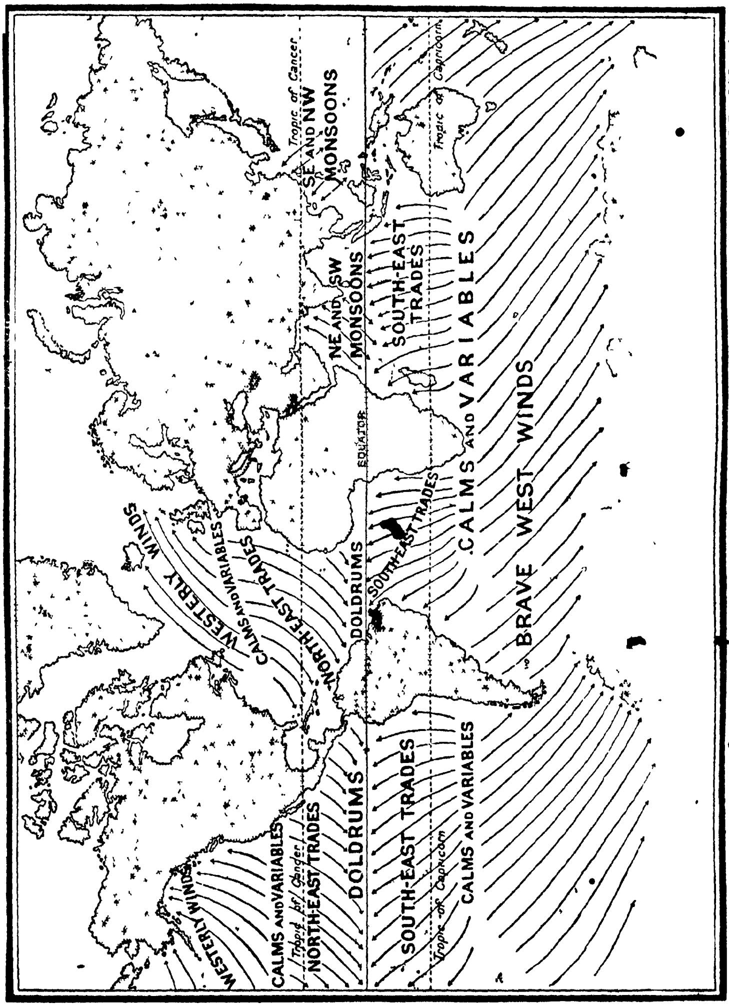
1. Over the Equator and over the Poles there is low pressure.
2. Over the Tropics there is high pressure.
3. From the high-pressure regions the air blows outwards in two directions. There are north-east and south-east trade winds towards the Equator, and south-westerly and westerly winds towards the Poles.

Belts of Calms.—The belt of Equatorial calms is called by sailors the *Doldrums*. This is an old word meaning dulness and sadness. They applied it to this part of the ocean because here they were becalmed for weeks together. There are also two belts of calms over the Tropics known as the *Calms of Cancer* and *Capricorn* respectively. This is the great region of high pressure, and here the currents of air from the north and from the south meet, one from the north-east and the other from the south-west. The movement of the air in these regions is upward from the earth and downward from the upper currents towards the earth, just as it is at the Equator. Where the westerly winds meet the Polar winds there are also two belts of calms called the *Polar Calms*.

Periodical or Seasonal Winds.—These are also known as the *Monsoons*. They are caused by the unequal heating of land and sea, the land being the continent of Asia and the sea the Indian Ocean and the South Pacific. There are two monsoons because of the swing of the line of greatest heat (see Lesson 51) from north to south in summer and in winter. A south-west monsoon blows from the Indian Ocean over India from April to October. It brings a great deal of rain with it. A north-east monsoon blows from October to April from Central Asia over India. It comes chiefly from the land and is often called a dry monsoon, because it brings very little rain with it. Over China and the south-east of Asia the monsoons are from the north-west and the south-east.

Fig. 68 shows by arrows the direction of the great world-winds which have been described.

Storms, Cyclones, Anti-cyclones, Isobars. — Besides these seasonal winds, there are others which are variable or local.



Stanford's Geog! Estab!, London

FIG. 68.—GREAT WINDS OF THE WORLD.

They, too, are caused by the movement of air from an area of high pressure, over which there is a column of dense heavy air, to one of low pressure, over which the air is rarer and lighter.

Such a movement may occur more or less suddenly, and if rapid and violent it is known as a storm, and may be accompanied by heavy rain.

The inflow or rush of denser to rarer air is always in a whirl inwards and upwards. This whirl or spiral movement may be seen in the little whirlwinds of dust that often rise on a dusty road. We cannot see the whirling air, it is true, but we can see the dust and leaves as they are blown upwards by the wind, till, at the top of the whirl, they spread out, fall outwards and sink back to the ground. And we can see the little whirlwind moving along the road, spinning as it goes, and whirling up more dust, till at length it dies away. This is precisely what happens, on a vast scale, in the air, when the storm is termed a *Cyclone.*[1] The centre of the cyclone is an area of low pressure over a tract, it may be, of a thousand miles. The column of air may be five or six miles high, and it may move onwards or travel along the earth's surface, spinning as it goes, at the rate of 15 to 30 miles an hour and sometimes at the rate of 70, 80, 120, or even 150 miles an hour.

Every cyclone or low-pressure area sucks in, so to speak, at the bottom, a current of air which rises, whirling rapidly upwards, till it flows over at the top. And every high-pressure area, or huge column of dense heavy air, flows slowly downwards and then outwards, at the base; for heavy air sinks by the law of gravity. This downward flow of air, which is the exact opposite of the cyclonic movement, is termed an *Anti-cyclone.* The rate of movement of the air in the latter is much slower than in the former. When we talk of cyclones we think at once of storms of wind and rain, while in an anti-cyclone there is a light breeze often scarcely perceptible.

In the West Indies cyclonic storms are called *Hurricanes*, and in the China Seas they are termed *Typhoons*. Terrific whirlwinds of sand and dust over the land in the vast desert of the Sahara are termed *Simoons*. In N. America, the whirlwind which often arises on the outskirts of a cyclone is known as a *Tornado.* In all these storms the cause is the same, being a rush of air from a high-pressure to a low-pressure area. The closer the areas, the more violent is the storm.

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[1] Greek *cyclos*, a circle.

The whirl of the air in a cyclone is due to the rotation of the earth from west to east. The direction of the whirl is from left to right in the northern hemisphere, *i.e.* in the same direction as the hands of a clock move. In the southern hemisphere, the direction is from right to left, or anti-clockwise as it is sometimes termed. This is true of all moving bodies on the surface of the earth. It is known as "Ferrel's Law." Another law of the winds arising from the same cause was first stated by the Dutch Professor Buys Ballot. It is: that the high-pressure area is always to the right, and the low-pressure area to the left, of a man standing with his back to the wind in the northern hemisphere, while in the southern hemisphere the same thing is true for a man facing the wind.

We saw that isotherms, on a map, are lines connecting places with the same temperature as measured by the thermometer (corrected to sea-level). Similarly we may connect by lines on a map, places where the weight or pressure of the air is the same at any given time. Such lines are called *Isobars*,[1] or equal-pressure lines. An isobar is named after the degree of the barometer (corrected to sea-level) which it expresses. Thus the isobar 30° shows that on all the places through which it passes, the pressure of the air at any given time is 30°. Further remarks on isobars will be found later, in Lesson 32.

EXERCISES.

1. Describe the causes of: (*a*) land breezes, (*b*) sea breezes.
2. What and where is the Belt of Equatorial Calms?
3. Describe and account for the North-east and South-east Trade Winds.
4. How does the rotation of the earth affect winds?
5. What are the Brave West Winds? Account for the other name, "the Roaring Forties."
6. What are the Doldrums, and why are they so called?
7. Describe the Monsoons, their causes and effects. Why are they so called?
8. State (*a*) Ferrel's law, (*b*) Buys Ballot's law.
9. Describe and explain the cause of a cyclone. What different names have cyclones in various regions of the world.

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[1] Greek *isos*, equal, and *baros*, weight.

23. THE OCEAN AND ITS MOVEMENTS.

TIDES.

THOSE who live on the seashore observe that, *twice* every day, the sea comes forward on the land, if it be a low beach, and then goes backward to where it was before. If the coast be a steep cliff, the sea rises up the cliff a foot or two above sea-level and then sinks again to its former level. This movement of the sea, forwards and backwards, is very slow. Inch by inch the water creeps up for six hours, and inch by inch it goes back for the next six hours. But twice in the month the water rises higher than it does the rest of the month.

This rise and fall of the sea is known as the *Tides*. The forward movement is called the "flow" of the tide, and the backward movement is the "ebb." The times of these tides never vary. They are as regular as the rising of the sun and moon, and may be foretold years beforehand. They are not caused by the wind. The tide flows on as usual even when the strongest gales blow in the opposite direction.

When the sea is advancing, it is a "flood tide," when it is retreating, we have the "ebb tide." These movements are also known as "high tides" and "low tides." The highest line on the beach reached by the incoming sea is called "high-water mark." The lowest line it reaches, when it retreats, is "low-water mark." The sloping part of the beach between the high-water and the low-water marks is called the "foreshore."

Fig. 69 shows the high- and low-water marks very clearly. The edge of the sea is low-water mark. It is along the left of the picture. On the right, there is the foreshore, with the high-water mark. Higher up, there are the banks worn away, where the waves of the sea have beaten upon them in storms. A boat which floated in on the flowing tide has been left on the sand by the ebb of the tide.

On the foreshore it will be seen that there are two high-water marks, one above the other. Twice a month, high water is higher and low water is lower than usual. In other words the tide is stronger than usual and covers more of the shore. There is then what is called *Spring tide.* The other tide is the *Neap tide*, when the sea does not come so far up the land nor go back so far. It has always been seen that these tides follow the movement of the moon. At new moon and at full moon there are spring tides. In the first and last quarters of the moon there are neap tides. How are tides caused?

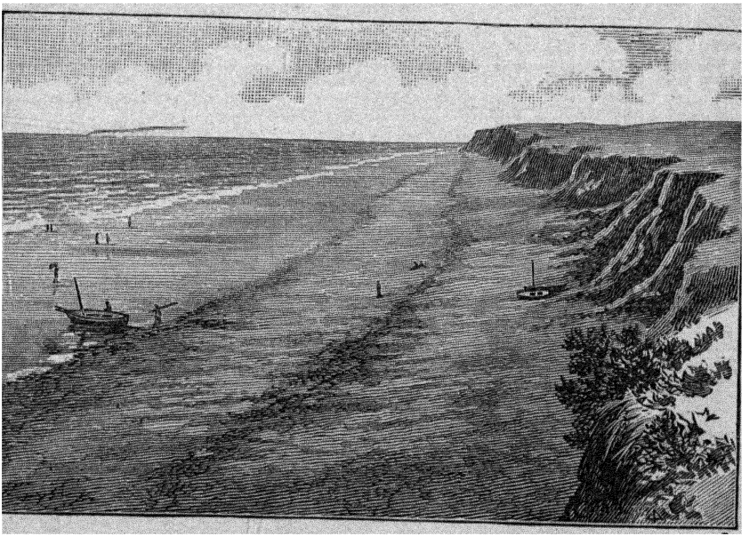

FIG. 69.—HIGH AND LOW TIDES.

Fig. 70 explains the tides. There is the sun in the middle of the figure. The earth is shown at two points of its orbit round the sun. At the top of the figure there is the moon at two points of its orbit round the earth—when it is full moon and new moon. At the bottom of the figure we have the moon at two other points of its orbit—when it is in the first and last quarter. With this figure may be compared Fig. 23 (in Lesson 8), which shows the phases of the moon.

Both the sun and the moon attract the earth. They attract the globe of the earth and the ocean of water resting on it.

The earth also attracts the water. There are thus three forces acting on the water. Attraction (see Lesson 7 on Gravity) acts between all bodies in proportion to their size and *inversely as the square of the distance* between them. The earth is close to the ocean, which is touching it. Its attraction is the strongest of the three. The ocean cannot leave it. The attraction of the moon is the next strongest, for it is much closer to the ocean than the sun, although the sun is immensely larger. The force with which the sun attracts the ocean is not even a half of that of the moon.

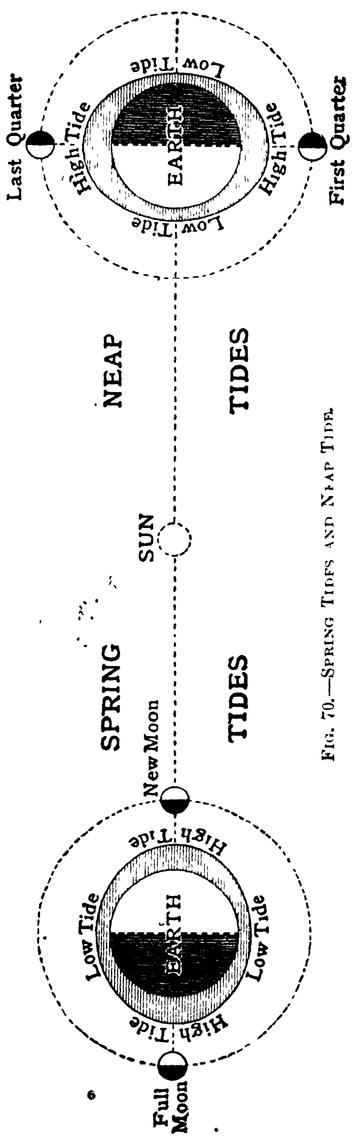

Fig. 70.—Spring Tides and Neap Tide.

Water, being a liquid, yields easily to the force of attraction. It cannot leave the earth, but it rises up towards the moon as it passes over it, and towards the sun as the rotation of the earth brings one part of the earth after another directly opposite the sun.

The moon attracts both the globe of the earth and the ocean on it. That part of the ocean opposite to the moon is nearer to it than the earth is. The water is pulled up towards the moon. But, at the same time, the earth is nearer to the moon than the ocean on the other side of it is. The earth is, so to speak, pulled partly out of the ocean on the other side, which remains heaped up behind. Thus the pull of the moon causes a rise of the water on two sides of the earth, the side opposite to it and the other side, *i.e.* the antipodes. At the same time the water on the surface at right angles to the pull, where the moon's attraction is least, is low tide on both sides of the earth.

The same effect, precisely, is produced by the pull of the sun, but in a less degree because the attraction of the sun is not so strong.

But, twice in the month, at New Moon and at Full Moon, the moon is in the same line as the earth and the sun. The sun and moon are then said to be in conjunction, and they pull the water in the same direction. The force of attraction is then the *sum* of the two attractions, *i.e.* it is that of the moon added to that of the sun. The tide rises much higher and is called the *Spring tide*, as shown in the bottom figure.

Also, twice in the month, in the first quarter and the last quarter of the moon, as shown in the lower figure, the attraction of the sun acts *against* the attraction of the moon. The sun and moon are then said to be in quadrature, *i.e.* at right angles. The moon and the sun are pulling the water different ways. The force is now the *difference* of the two attractions. The tide rises much lower than before. It is called the *Neap tide.* At Calcutta, far up the River Hoogly, the water rises about 15 feet at spring tides and about 6 feet at neap tides.

In the open ocean, the rise of the tide or *tidal wave* may be only a foot or two and even less. In a land-locked sea, like the Mediterranean or Baltic, it is only a few inches, so that seas like these are practically tideless. But when the tidal wave comes to shallow water, or to a narrow bay with a wide opening, it is heaped into a great wave. In the Bay of Fundy, in North America, it rises to 70 feet, this being the highest tide in the world. In the Bristol Channel, which opens to the west, the tide rises more than 40 feet. As it passes into the narrow mouth of the Severn, the tide forms a wave two or three feet high. This tidal wave is called a *Bore.* Bores are also formed in the estuaries of the Amazon, Hoogly, Yang-tse-kiang, and other rivers.

Th[illegible] of great use in two ways. They scour out and clean the estuaries and mouths of great rivers which are often full of the refuse washed into them by great cities on their banks, and carry the refuse away to a distance in the ocean as they ebb. Also they make it possible for large ships to enter ports which they could not reach without the tide. Most of the openings from the North Sea, *e.g.*, are shallow, but when the tide raises the water at their mouths from 5 to 20 feet, they admit very large ships and become excellent harbours. "If the North Sea were tideless like the Baltic Sea, London would be an inland town far out of the reach of shipping." But large ships and great steamers and huge barges float up the Thames quite easily, on the flood tide, right into the heart of London.

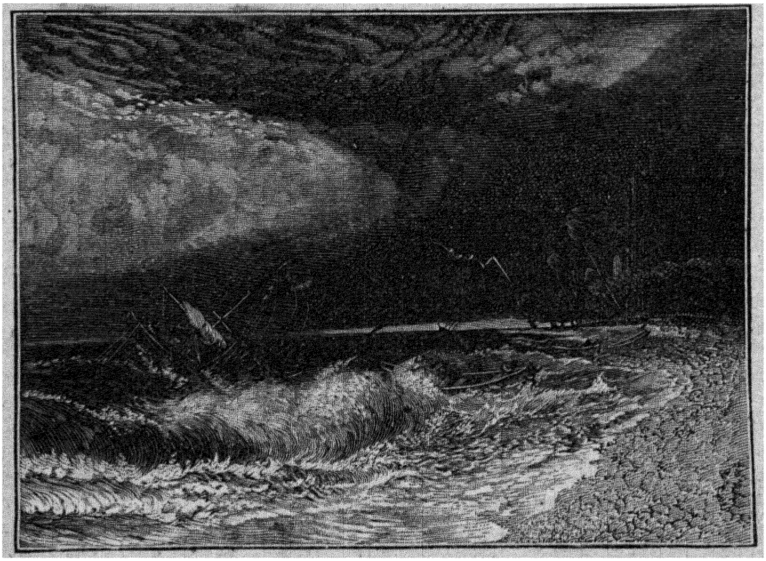

FIG. 71.—BORE IN THE HOOGLY RIVER.

EXERCISES.

1. Describe the tides and explain what causes them.
2. Distinguish between Spring and Neap tides.
3. What is a bore? Describe some remarkable bores.
4. How do the tides benefit us?

24. THE OCEAN AND ITS MOVEMENTS (*contd.*).

CURRENTS.

THE rocky crust of the sphere of the earth is the Litho-sphere. The air resting on it is the Atmo-sphere. The ocean of water may be called the Hydro-sphere or water-sphere. It covers about three-quarters of the earth's surface, the rest being land. The surface of the ocean, when calm, is everywhere more or less on the same level. We call it the sea-level, and from it we measure height upwards and depth downwards.

If there were no water in the ocean, so that we could see the bottom, we should find that it looked very much like the surface of the land. On it there are vast plains, deep valleys, huge plateaus, high peaks and ranges of lofty mountains. All ocean islands are merely the summits of ocean mountains, of which the bases and slopes lie far below, in the water. The long lines of islands along the eastern coast of Asia are the summits of a lofty range of volcanic mountains, like the Andes of South America, rising from the depths of the Pacific Ocean.

The form of the land that lies beneath the ocean has been ascertained by "sounding," *i.e.* by letting down long lines of wire rope, with weights at the ends, into the sea. The weight sinks to the bottom and the length of the line that goes under water shows the depth. The greatest depth in the Atlantic Ocean is in the West Indies, where it is over 27,000 feet. In the Pacific Ocean, near New Zealand, a depth of about 30,000 feet has been found. The height of the ocean mountains rising from these depths is much the same as that of the highest land mountains, *e.g.* the Himalayas.

The great oceans of the world—the Atlantic, the Pacific, and the Indian Oceans—were probably formed in the way described in Lesson 11, when large tracts of the cooling crust of the earth were raised and formed continents, while other large tracts sank and were filled by the inrushing water, now called seas, bays, and gulfs. The Arctic and Antarctic Oceans were probably formed in the same way.

There are smaller seas, which may be called *Enclosed Seas.* They are nearly surrounded by land, *e.g.* the Mediterranean, the Black Sea, the Sea of Marmora, and the Baltic Sea in Europe; Hudson Bay and the Gulf of Mexico in North America; the Red Sea, the Persian Gulf, and the Japan Sea, and Sea of Okhotsk in Asia. These seas are shallow when compared with the oceans, and were probably formed long after them, by the sinking of smaller tracts in the middle of the land. Other seas are termed *Inland Seas,* such as the Caspian Sea and the Aral Sea. The water in them is salt, and seals and other ocean animals are found in them. They are probably parts of an ocean which once covered Siberia and the Steppes north of the Caucasus, but retreated northwards when the land uprose beneath it.

There is a ceaseless coming and going of water between the sea, the air, and the land, by evaporation. But the vapour that is always rising from the sea is pure water, while the water in the sea is salt. The salt does not evaporate. It is left behind. The sea, however, does not get salter and salter, so far as we know. There are three reasons for this. The rain which falls into it is nearly pure water. The rivers pour into it water which is comparatively fresh, although it also contains some salts. Lastly, the salts in the sea-water are continually being taken out of it by enormous masses of sea-plants, floating in the water, and by countless millions of tiny marine animals whose shells and bones are made out of the sea-salts. They sink to the bottom and make sedimentary rock.

The temperature of the surface water of the ocean varies like that of the air, and is due to the same causes. It varies with the seasons, with latitude, and with the direction of the great ocean currents. The sun shines upon the sea as well as on the land and the zones of sun heat include the sea as well as the land. There is a broad belt of warm water in the hot belt, in the Tropics, where the average annual temperature is 80°. In the Red Sea it often rises to 100°. To the north and to the south of the Equator, we find that the water gets cooler and then colder as we pass from the cool to the cold zones of the earth. In the Polar seas, the temperature sinks to 32°, the freezing-point, and here the surface is covered with ice. The water in the great depths of the ocean, however, is always very cold in all latitudes, even in the Tropics.

The air over the ocean is warmed or chilled by it, according to the temperature of the surface water on which it rests. It spreads the warmth or the coldness, which it gets in this way, over the land across which it moves. Warm water laving the shores of a country does not make the land warm by touching or flowing up to it. But the warm wind, coming from warm water and blowing over the land or resting on it, warms it. The climate of a country over which warm winds (usually westerly) blow, is therefore warm, while cold northerly winds (in the northern hemisphere) make a climate cold.

A movement of the ocean—the flow of its water in any direction—is called a *Current.* Currents are caused in three ways. There are currents due to convection, where cold water takes the place of warm water and warm water that of cold water; wind or drift currents, where the surface water is driven along by the wind; and tides, due to the attraction of the moon.

Convection Currents.—These are exactly like those shown, on a small scale, in Figs. 66 and 67. There is a constant flow of cold water from the icy Polar regions towards the Equator. The heavy cold water at the Poles sinks to the bottom and creeps along the bottom of the deep seas towards the Tropics. Above it, the warm upper layers of water move in the opposite direction, from the Equator towards the Poles, to take the place of the water that has moved away. When the cold water reaches the equatorial region, it rises to the surface to take the place of the water which has moved away. There it is gradually warmed, and moves back again as a surface current towards the Poles. There is thus a constant circulation of salt water, warm upper currents moving towards the Poles and colder lower currents moving towards the Equator. That the surface water is as a rule warm, and the lower water cold, has been proved by thermometers, made for the purpose, which are let down into the sea and mark the temperature at different depths.

Wind-waves are caused by the wind blowing continuously over the surface of the water, which rises and falls in long lines, just as the tops of the stalks in a cornfield bend and rise again under a wind blowing over them. A very strong wind will often raise waves from 30 to 40 feet high. After a storm, the waves continue to heave and roll for a long time after the wind has ceased. This heaving water is called *ground-swell.* When it reaches a reef of rock in the ocean, it breaks against it and is called *breakers.* Where the rolling waves come to a low beach they break in long lines of *surf.*

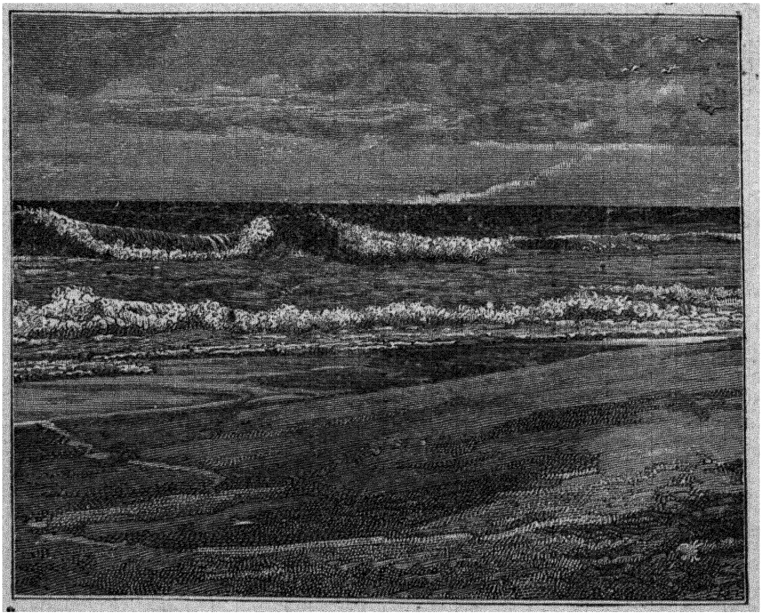

FIG. 72.—SURF ON A BEACH.

Wind or Drift Currents.—When a wind blows over the ocean, it pushes or drives along an upper layer of water, which may be of any depth, according to the strength of the wind, from a few feet to about 500 feet. It drives the water along in the same direction in which it is blowing. The winds, therefore, show us the direction of the currents. The currents of water follow and depend upon the currents of air above them. This will be clear if Fig. 73 of the great ocean currents be compared with Fig. 68 of the chief winds of the world. In both maps the arrows show the direction in which the currents of air and water flow.

The Equatorial Current.—The trade-winds drive the surface water of the ocean towards the Equator. The N.E. trade-wind and the S.E. trade-wind set in motion two great currents, which unite when they meet and flow in a general westerly direction as the Equatorial Current across the Atlantic and Pacific Oceans. The rotation of the earth from west to east also makes the water flow in a westerly direction along the Equator. The depth of this current is about 300 feet, and the rate at which it moves is about 18 miles an hour. If there were no land masses in the way, this broad stream of warm water would flow right round the globe, moving slightly to the north in summer and slightly to the south in winter, under the line of greatest heat of the solar rays. But the continent of America, which divides the Atlantic Ocean from the Pacific, divides all the great ocean currents into two systems, one of which may be called the Atlantic and the other the Pacific system, as Fig. 73 shows very clearly.

The names of the currents in each ocean may be learned from Fig. 73, and the direction in which they flow is shown by the arrows.

One of them, however, may be described in more detail. *The Gulf Stream* is one of the great currents of the N. Atlantic ocean. The South Equatorial Current, driven onward by the S.E. trade-winds, may be said to start from the west coast of Africa. It then flows across the Atlantic to South America, which here projects far into the sea. Here the current divides into two branches. The smaller flows southwards, but the larger branch flows round the coast northwards into the Caribbean Sea and the Gulf of Mexico. Here the air is very hot. The current under the name of the Gulf Stream flows through the Strait of Florida as a warm and swift "ocean-river" into the open sea. It here has a breadth of about 50 miles, a temperature of about 81°, and moves at the rate of about 5 miles an hour. It is joined by the North Atlantic drift. It then bends away

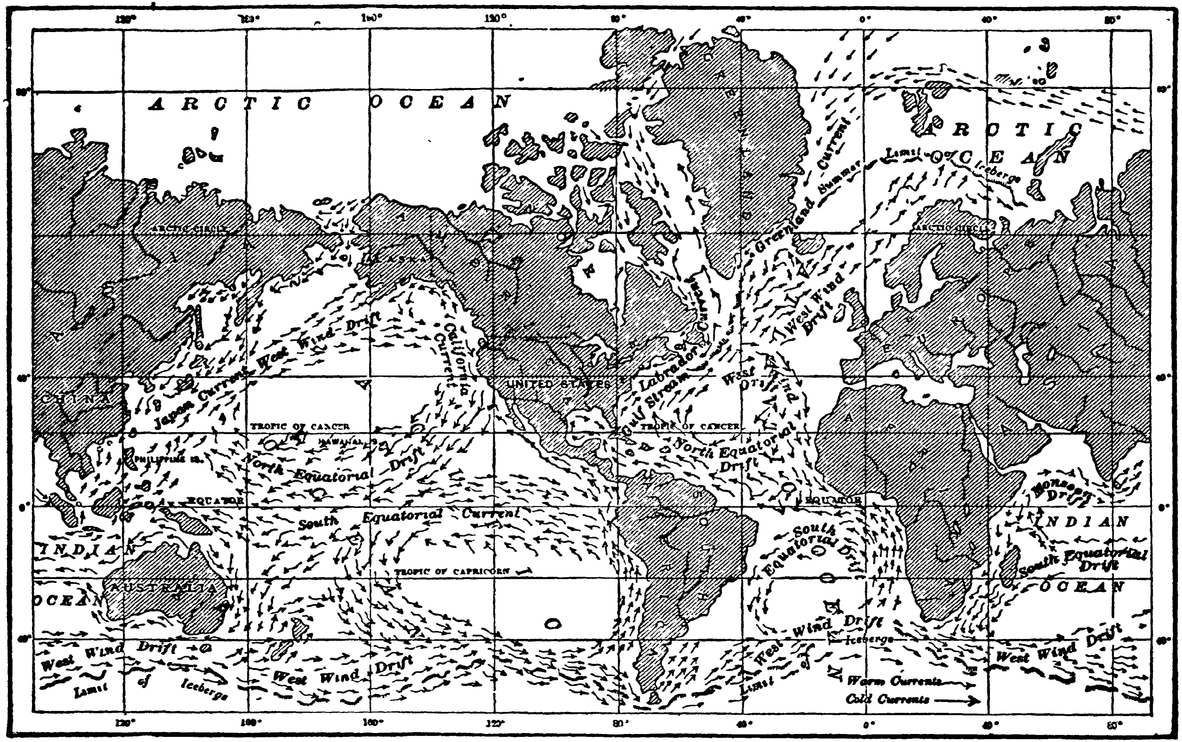

FIG. 73.—THE GREAT OCEAN CURRENTS.

to the north-east, but spreads out, flows more slowly, and is lost in the North Atlantic drift, which, as a wide stream of comparatively warm water, is driven by the south-westerly winds past the western shores of the British Isles to the north of Norway. The air current over this stream is warm and filled with water-vapour. It carries warmth and rain over the west of Ireland and England.

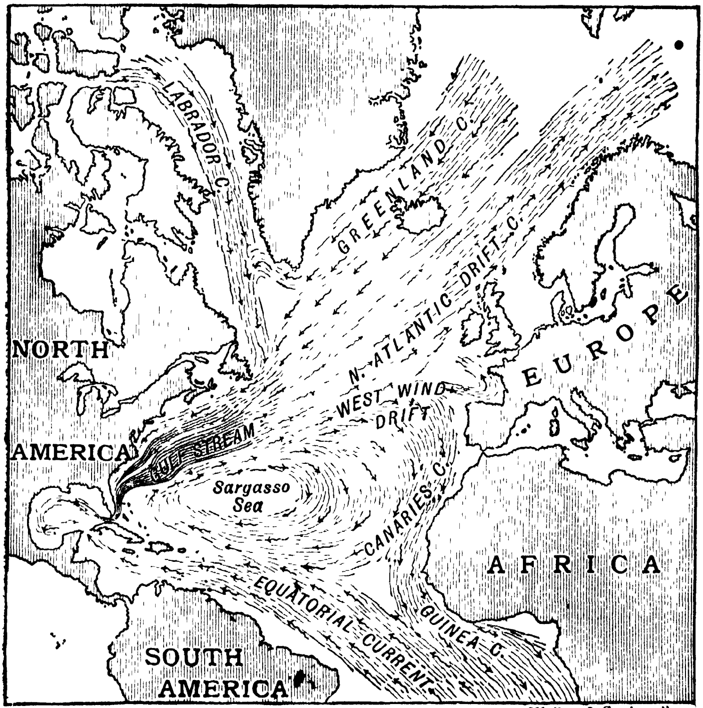

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FIG. 74.—CURRENTS IN THE NORTH ATLANTIC.

Within the sweep of the Gulf Stream lies a wide area of calm water known as the Sargasso Sea. Great quantities of seaweed (*Sargassum*) grow in it and give it its name.

The Labrador Current is a stream of ice-cold water, filled with icebergs, which comes down the east coast of Labrador and North America as far as Newfoundland. The air over it is intensely cold. It blows over the east coast of North America and makes the climate there much colder than that of the British Isles, which lie in the same latitude. Off the coast of Newfoundland, the moist air which rises from the Gulf Stream is condensed by the cold air from the Labrador Current into heavy fogs, dreaded by sailors. Here the giant steamer *Titanic* struck an iceberg in 1912, and over 1600 passengers lost their lives.

EXERCISES.

1. Distinguish between a current and a tide.
2. Give instances of—(*a*) enclosed, (*b*) inland, seas. Why does a cubic foot of water in the Atlantic contain less salt than the same quantity of water in the Dead Sea?
3. Account for the different temperatures of the water in the various seas and oceans of the world.
4. How does the nearness or distance of the ocean affect climate on land?
5. Describe the main currents of the ocean.
6. What is the Gulf Stream, and how is it caused?
7. Describe the Sargasso Sea. Why is it so called?

25. CLIMATE.

THE term *climate* we get from the Greek word *klimata*, which means *slopes.* The old Greek geographers were probably thinking chiefly of the mountain slopes of their country when they first used this word. They knew that the air felt colder as they went up the slopes of the mountains.

We use the word climate in a wider sense. It is the *average state of the weather*, as regards temperature and moisture. We talk of the weather every day. We say, "It is fine weather to-day," if the sky is bright and clear and the air feels fresh and pleasant. We say "It looks as if we shall have bad weather to-morrow," if the sky is covered with clouds and the wind is rising. Taking all the days in the year, if in any place there be many more rainy days than clear days, we say that the climate is *damp* or *moist.* If the weather does not change much from day to day, we say that the climate is *equable.* If it be never very hot nor very cold, we call the climate *mild* or *temperate.* If it be sometimes very hot and sometimes very cold, we say that the climate is *extreme.*

Climate depends mainly upon the temperature of the air and the amount of moisture in it. It is the air around us that warms us or chills us. We have already learned the causes of changes in the temperature of the air, and therefore we know upon what climate depends, that is to say, we know what the *factors* of climate are. A factor (Latin, *fac*, "make") is what makes or causes.

The chief factors which determine the climate of any place are these:

1. Latitude or distance from the Equator.
2. Altitude or height above sea-level.
3. Situation as regards sea and land.
4. Prevailing winds.
5. Soil and vegetation.
6. Position as regards ranges of hills or mountains.

Latitude.—The lower the latitude of a place is, the higher is the temperature of the air around it (at the sea-level), the more the moisture in the air and the heavier the rainfall. Places in the Tropics are within the range of the direct rays of the sun. Places beyond the Tropics get only the oblique rays, and the farther from the Tropics they are the more oblique are the rays. And, as we saw in Lesson 22, the heaviest rainfall is in the Tropics, where there is a zone of constant rain.

Altitude.—The higher a place is above the level of the sea, the less warmth the air around it gets from the dark heat rays from the earth. There is less air above it, and this air is much rarer than the air at the sea-level. As we saw before, the air acts as a blanket to the earth, it keeps in the heat and prevents it from rising from the surface by radiation. The denser the air, the thicker and warmer the blanket; the rarer the air, the thinner the blanket.

The various degrees of temperature of the air—from hot to warm, warm to cool, cool to cold, and cold to freezing—as felt in going from the Equator towards either of the Poles, are also felt in going up a high mountain, even though it rise from the line of greatest heat in the Tropics. There is perpetual snow above the height of about 13,000 feet on the southern face of the Himalayas, while the thermometer may show 100° of heat in the steamy plains of Bengal at the base, in the same latitude.

At great altitudes, the air is very dry, for cold air cannot hold moisture. But at lower altitudes, *e.g.* on the Western Ghats in the Deccan and on the Khasi hills in Assam, there is very heavy rainfall when the wind blows in from the sea.

Situation as regards land and sea. This factor of climate is very closely connected with the next and depends upon it. Places nearer the sea have, as a rule, a much milder climate than those which are far inland. The climate of such places is often called *maritime* and sometimes *insular*, because islands have it in perfection. Such places have cooler summers, warmer winters, and moister air than inland places far in the interior of a continent. Here the climate is called *continental* or *extreme*. But the mildness of countries with a maritime climate is due to the winds which blow over them. Warm sea-water washing the coast of a country does not warm it by conduction. The heat does not pass to the land from the water directly, although the one may be touching the other. The warmth in winter, and the coolness in summer, are carried by the wind blowing from the sea to the land. For this reason, countries situated on the shores of the ocean, *e.g.* France and Spain in the west of Europe, have a far milder climate than countries like Poland and Russia in the east of Europe, where the sea is at a great distance.

Prevailing Winds.—Upon the direction of the winds depends largely the temperature and the rainfall in any country. The British Isles have a far milder climate than Newfoundland in the same latitude, because the warm south-westerly winds from the Atlantic blow over them for many months in the year, while Newfoundland, in the same latitude, is exposed to the icy blasts from the Labrador current blowing down from the Arctic Ocean.

Soil and Vegetation.—Wet marshy ground makes the air above it damp and cold. Heavy fogs lie over land like this. Different kinds of rock, and the soil formed from them, absorb and radiate heat at different rates. Sandstone and loose sand heat up, cool down, and dry up very fast. The great sandy deserts of the earth are intensely hot in the daytime, but radiate their heat so quickly into the dry air above them that they are bitterly cold, often at freezing-point, in the night-time. The climate is so extreme that the thermometer often ranges from 100° to 32° in twenty-four hours. If the soil be fertile and covered with forest, the temperature of the air above it is cooler in the day and warmer at night than if the ground were bare, for leaves of trees do not heat rapidly.

Position as regards Ranges of Hills or Mountains.—The side of a mountain range on which wind blows is the windward side. The other side away from the wind is the leeward side. Ranges of hills shelter countries on their leeward side, just as a high wall shelters a man who stands behind it in a gale of wind. Warm moist winds from the ocean blow upwards along the slope of a chain of mountains opposite to them, and the moisture is condensed as the wind reaches the summit and falls on the windward side. The countries on the other or leeward side get no rain or very little, and have a dry climate. This is the reason why countries on the west or windward side of the Western Ghāts in India get so much rain and have such a damp climate, while the countries on the eastern or leeward side have a very dry climate. The Himalayas shelter the valley of the Ganges from cold northerly winds, and the countries in this valley have a warm climate. They also shut out the warm equatorial winds from Tibet and the plateau of Central Asia, where the climate is extreme.

CLIMATIC REGIONS.

Bearing in mind the factors of climate, we may divide the surface of the earth into tracts or regions, each of which has more or less the same climate, and therefore the same class of plants and animals, other than man. Man can live in almost any part of the world. He can wear more or less clothing according to the climate, he can build a house to shelter himself from bad weather, he can warm himself by fires. Other animals and plants cannot do all this. Plants can only grow in a climate that suits them, and animals, other than man, especially wild animals, can only live in a climate suited to them. Birds, indeed, migrate, or fly from cold lands to warm regions, living in different countries at different seasons, but beasts cannot do this.

A *climatic region*, or "geographical unit" as it is sometimes called, has therefore its own kind of land, its own climate, and its own plants and animals. A region of this sort is very different from a "country," which is a division of land under one government. A region may include several countries; *e.g.* Holland, Belgium, and Denmark are three countries all in the same region. On the other hand, a large country, such as the United States of America, includes several climatic regions.

The first and clearest division of land that can be made into natural regions is that shown in Fig. 16, which divides the whole surface of the earth into wide spaces or belts in accordance with their temperature.

These divisions are: (1) the Tropics or Hot belt, (2) the Warm Temperate belt, (3) the Cool Temperate belt, (4) the Cold belt.

These broad belts or zones of temperature stretch across the earth from east to west, like the parallels of latitude. They pass through all the continents.

But each of the continents is surrounded by the ocean, and nearness to the ocean is another factor of climate. A region bordering on the ocean has a maritime climate, while the interior of a continent has a climate that is extreme or continental. The direction of the prevailing winds may to some extent affect these conditions.

We have, therefore, to subdivide the four great natural divisions already mentioned. Each continent may be roughly divided into three long strips or spaces from north to south, more or less in the same direction as the meridians of longitude. These spaces will be: (1) the eastern margin, (2) the western margin, (3) the interior, lying in the centre, between them. Also, in the south of Asia—which does not run, like America and Africa, from north to south, but from east to west, and presents a broad face to the Indian Ocean—there is a monsoon region. These five regions may be considered subdivisions.

There is also another important factor of climate—altitude. This gives further subdivisions into (1) lowlands or plains, (2) plateaus and mountain ranges.

Thus we have the following regions with their subdivisions:

I. *The Cold belt*, *i.e.* the Arctic or Polar regions.
  1. Lowlands or Tundras.
  2. Highlands, often called the ice-caps of the world. They are cold deserts.

II. *The Cool Temperate belt.*
  1. Western margin—maritime.
  2. Eastern margin—maritime.
  3. Interior highland—cold.
  4. Interior lowland—extreme

III. *Warm Temperate belt.*
  1. Western margin—maritime.
  2. Eastern margin—extreme, owing to the winds.
  3. Interior highlands—extreme.
  4. Interior lowlands—extreme.

IV. *The Hot belt or Tropics.*

Here the great heat and constant rain gives us subdivisions of a different kind. They are:

1. Monsoon lands—wet and warm.
2. Interior—dry and warm.
3. Deserts—extreme.
4. Highlands—extreme and cold where very high.

We need not here name the countries in each of these regions. It will be a useful exercise to find them in the maps of the continents in this book. Remarks on the climate of the various countries of the world will be found in the description of each given later on in this book.

EXERCISES.

1. Distinguish between climate and weather.
2. What are the brief factors of climate? Describe the operation of each.
3. Give a striking instance of the effect of each of these factors in some country in each continent.
4. How is it that the division of the earth's surface into zones of temperature, corresponding with latitude, is not sufficient to mark the climate of the countries in each of these zones?
5. Make a rough division of the climatic regions of the world with the subdivisions of each.

26. PLANTS AND ANIMALS OF THE WORLD.

ZONES OF VEGETATION.

EACH of the chief climatic regions has its own plants and animals. There they flourish, though some animals, which belong properly to one region, may be found in another, to which their ancestors strayed in past ages. But when this is the case, their colours and even their habits and their food change, so as to suit the new region where they have lived for perhaps thousands of years. The fox, *e.g.*, is found in nearly every country, but in the Arctic regions it is white and lives on fish, in other regions it is grey and eats tame birds, which it steals from farmyards; elsewhere it is brown, and its food is the flesh of wild birds which it catches. The bear is black or white or brown in different regions, and it lives on fruit or flesh or fish according to the region which it now inhabits.

Although the eastern and western hemispheres have more or less the same kind of climatic regions, the same soil, and the same temperature, yet we find that in the Old and New Worlds the animals, though they may be of the same kind, are not the same in size and appearance, and therefore have different names. Instead of the Old World lion we find, in the New World, the puma; for the tiger, we find the jaguar; for the huge elephant, hippopotamus, and rhinoceros, there is the much smaller tapir; the camel is replaced by the vicuna; and instead of apes and baboons, we find flat-nosed, long-tailed monkeys.

The first home of a plant or animal is often called its *habitat*. Here the climate suits it exactly. Animals often wander into other regions close by, where the more hardy of them continue to live. The chief barriers to the migration of animals are the sea, deserts, and lofty mountain ranges. The animal (other than man) which has wandered farthest is the dog, which was tamed by man at a very early period and went with him wherever he went, and is now found in every region and every part of the world. A dog can eat whatever man can eat. In cold climates he lives in his master's house or hut, and his skin grows thick and is covered with hair to keep him warm. In warm climates he lives in the open air and his skin is thin.

When we look only at the flora or vegetation, *i.e.* the plants large or small, that grow on the earth's surface, we may divide the land into—

Forest, Grass-land, Desert.

In a *forest* the trees grow thickly, close to one another. It is too dark for grass to grow underneath them, for grass will not grow out of the sunlight. On the outskirts or margin of a forest the trees open out, grass grows and there are wide grassy glades. Here there is *park-land* or *wood-land*. Gradually, as the climate changes from hot to warm or cool, and there is less rainfall, we have wide belts of *grass-land*, where trees are few and far between and where there are often no trees at all. As the climate gets colder, even grass does not grow properly, there are only low thorny shrubs and mosses. *Deserts* are hot or cold. The former are covered with sand or loose stones and the latter with snow or ice, and in neither is there any vegetation. The ground is bare.

The general rule as to the plants or *flora* and the animals or *fauna* of countries is this—warmth is favourable and cold is unfavourable to animal or vegetable life. What plants want is *heat*, with *light* and *moisture*. The largest trees and the biggest land animals are found in the tropical region. As we go northwards or southwards from the Equator towards the Poles, trees and plants and wild animals get fewer in number and smaller in size. In the Arctic regions no trees at all are found, the plants are small and stunted, animals are very few in number, and even the men who live there are dwarfs. At the Poles all life ceases.

FIG. 75.—FIR (*Conifer*)

Plants get their food from the soil and the air. Their leaves take in carbon from the carbonic acid gas in the air, and their roots take in mineral food from the soil. But plant food in the soil must be dissolved in water to be absorbed by the roots. Therefore plants cannot live without water. Rainfall varies all over the world. Where there is abundant rainfall, plants of every kind grow and flourish. As rainfall diminishes, fewer and fewer plants are found. The rainfall map of the world shows us also the great forests of the world.

Evergreen trees are always in leaf, for as the dead leaves fall, others take their places. Teak, mahogany, and ebony are evergreens. *Deciduous* trees shed their leaves in winter and then their branches are bare. Nearly all trees in the British Isles are deciduous, *e.g.* the oak, the ash, the elm, and the beech. *Coniferous* trees have fruit in the form of cones. The pine, the fir, and the larch are all conifers.

The "*Zones of Vegetation*," corresponding, nearly, with the climatic regions of the earth, are, *roughly*, those given in Fig. 76. They show the chief "types" of vegetation in the latitudes marked by the figures on the right. *All* the land, *e.g.* between 20° and 30°, is not desert, but deserts are the *type* or chief feature of this zone.

1. *The Equatorial Forest belt* includes the zone of heavy rain and extends about 10° north and 10° south of the Equator. In the hot damp climate of this region, dense dark evergreen forests grow. Huge creeping plants, with stems a foot thick, cover many of the giant trees or hang from their branches. In the basin of the Amazon these forests are called *Selvas*. There, and in the basins of the Congo and the Zambesi, the growth is so thick that the ground below is in perpetual twilight. The monkeys that live in these forests go from tree to tree, 50 or 60 feet above the ground, and never come down. Palms of every kind and the banana flourish, especially near the sea. The animals whose proper home is the Tropics include lions, tigers, leopards, rhinoceroses, crocodiles, camels, and giraffes; huge serpents like the python and boa-constrictor; and numbers of birds of every size and colour. Here, too, huge monkeys live, the gorilla, chimpanzee, and orang-utan. There are countless swarms of insects, ants, flies, mosquitoes, spiders, and many others.

8. *Snow and Ice.*	90°
7. *Tundras.*	75°
6. *Pine Forests.*	55°
5. *Deciduous Forests.*	45°
4. *Steppes.*	30°
3. *Deserts.*	20°
2. *Tropical Grass-Lands.* *Monsoon Lands.*	10°
1. *Equatorial Forests.*	0°

FIG. 76.—ZONES OF VEGETATION.

The equatorial forests are full of valuable timber trees, such as mahogany and ebony. Here, too, grow trees which yield rubber, quinine, and many valuable drugs. The forest regions are inhabited by half-savage Indian tribes. But where man has cleared the forests away and cultivated the land, as in the extreme south of India and Ceylon, fruit and grains, especially rice, grow well, and civilised communities live there.

2. *Tropical Grass-lands.*—To the north of the Equatorial belt, the forests thin out and there are vast open stretches of grass-land known in America as *Savannas* and *Llanos* and in Australia as *Downs.* Grass, which requires sunlight and cannot grow under shade, here flourishes exceedingly, and these grass-lands make good grazing grounds. When the rainfall is good, the land is cultivated, and grain, which is merely the seeds of cultivated grasses, such as rice and wheat, grows well. In this region, however, the rain is variable, and there are frequent famines and droughts. In the African savannas, elephants, rhinoceroses, giraffes, and antelopes are found.

The *Monsoon Lands* lie in this belt. They include the tropical and sub-tropical parts of India and China, with the most fertile land and the densest population in the world. They are the home of the elephant, tiger, and bison; deer of many kinds, jackals, and other animals. Rice, wheat, millets, sugar-cane, tea, coffee, spices, indigo, tobacco, and other valuable plants grow in different parts of this region, some on the hills, and some on the plains, which are well watered by mighty rivers.

3. *Tropical Deserts.*—The great sand deserts of the world are found along the margins of the Tropical zone up to about Lat. 30° N. or S., very nearly under the Tropics of Cancer and Capricorn. This region is nearly rainless. In the northern hemisphere there are the Persian and Arabian Deserts, the Thar in India, the Sahara and Nubian Deserts in Africa, and the arid states of Central America. In the southern hemisphere we find the great desert of Central Australia, the Kalahari Desert in South Africa, and the desert coasts of North Chile and South Peru. They may be termed also the *Trade-Wind deserts* for they lie in the track of the trade-winds, which, blowing from the N.E. and S.E., that is, from colder to warmer regions, expand, and hold up any vapour that may be in them, instead of dropping it as rain. In North Africa they come across a

vast flat dry land surface, and can drop no rain. In Australia, the interior of the continent is shut off from the S.E. trades, blowing from the moist ocean, by the mountain ranges along the eastern coast. The moist winds blow up the eastern slopes of this range, are condensed by the cold air at the summit, drop their rain on the eastern slopes, and blow over the land to the west as warm dry winds.

In South America, the trade-winds blow across the continent up to the Andes and drop their rain on those lofty mountains, chiefly in the shape of snow, so that the strip of land along the west coast, including North Chile and South Peru, gets no rain and is a desert up to about the latitude of 30°.

The deserts of the Sahara and Arabia are the home of the camel, the "ship of the desert."

4. *Steppes* (partly desert) and *Grass-lands.*—These two belts of vegetation are in the *Temperate zone*, including the Warm Temperate and the Cool Temperate zones. In this zone are found most of the countries and great nations of Europe, North America, North Africa, and Australia. In many parts of this tract the natural vegetation has been much altered by man.

The rainfall on the land in the Temperate zone depends very much on the situation of land and sea, and the position of the mountain ranges. The climate varies much more than it does in the Tropics. In very ancient times the face of the land in nearly the whole of Europe was covered with dense forest, mostly deciduous. As men spread over the land and became civilised, they cut down great tracts of forest to make room for the villages and towns in which they lived, and for the cultivation of the land to supply them with food. Wherever the land was cleared, grass sprang up and afforded pasture for sheep and cattle. Thus the ancient forests have been replaced by wood-land, grass-land, and cultivated land.

In these regions there is moderate rainfall in many places and the country is watered by rivers. This is why men settled in them, for men settle only where they can find water. But there are vast tracts in Central Asia, in Southern Russia, in North America, and in South America, where there is scarcely any rainfall, where forest cannot grow, and where grass alone can flourish. Where there is a little rainfall there is plenty of good grass, suitable for pasture, such as the *Prairies* in North America and the *Pampas* in Argentina in South America. Where the rainfall is very slight indeed and the land is dry, a sort of very poor thin grass grows, and there are, here and there, patches of "scrub" (low thorny plants). These half-desert tracts are called *Steppes.* They occur in south-western Asia, the south-east of European Russia, part of Hungary, and the interior of Spain.

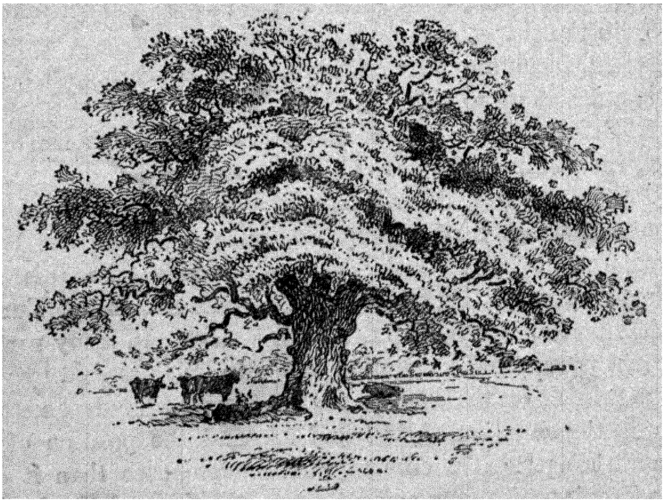


FIG 77.—OAK.

The driest regions of the steppes pass into true deserts, including the vast tract of sand and rock known as the Gobi or Shamo in Mongolia, the plateau of Tibet, and the sandy wastes in North America, between the Rockies and the mountains of California, called the "Great Basin."

5. The *Deciduous trees* in the inhabited and cultivated parts of the Temperate zone include the oak, ash, elm, beech, and birch, and in America the maple.

The wild animals of the Temperate zone are wolves, bears, foxes, wild cats, weasels, and badgers.

6. *The Pine Forests.*—In the northern part of the Cool Temperate zone, just below the Tundra region, there is a wide forest region of *Coni-fers* (cone-bearers). These hardy trees grow only in a cold climate which would kill other trees. The *Pine* is the most common of this class, which includes also firs, larches, and cypresses. Pines are found chiefly in Scandinavia, firs in Russia, larches in Siberia and North America. In Siberia this region of conifers is known as the *Taiga.* Pines are also found on the west of the Rockies as in Fig. 78, which is a picture of a pine forest in the Selkirk Mountains in British Columbia. In the foreground there is the Canadian Pacific Railway, which runs from the Atlantic to the Pacific Ocean.

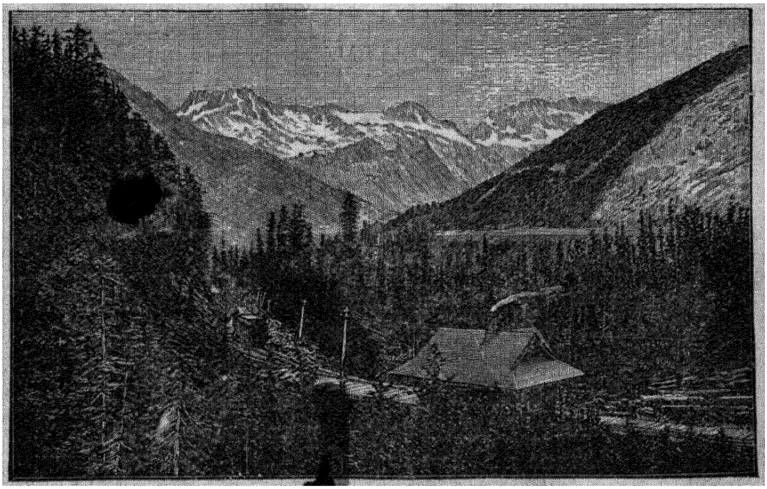


FIG. 78.—PINE FORESTS [illegible] THE SELKIRKS (BRITISH COLUMBIA).

The *Conifers* are so called because their fruit is a *cone*, as in Fig. 79, which shows the leaves and fruit of a pine.

The timber of the pine is a soft white wood called *deal*, out of which boards and boxes and matches are made. The soft wood is also made into paper. The sap yields tar, pitch, turpentine, and resin.

7. The *Tundras* are vast plains on the cold lands around the Arctic Ocean, in North America, northern Europe, and northern

Siberia. The soil is itself frozen deep. In winter the Tundra is a great snow desert, over which the Lapps and Samoyeds, who inhabit this dreary region, travel on sledges drawn by dogs or reindeer. In summer the rays of the sun, though feeble, thaw the snow and convert the soil into a swamp, which is soon covered with mosses, ferns, and even coloured flowers. Towards the south, stunted willows and birch trees grow, and the Tundra merges into the Taiga—the pine forests of the Cool Temperate zone. On the north, it passes into the snow and ice deserts of the Polar regions. The nomadic tribes which inhabit the Tundras live by hunting and fishing, and on the milk and flesh of the reindeer.

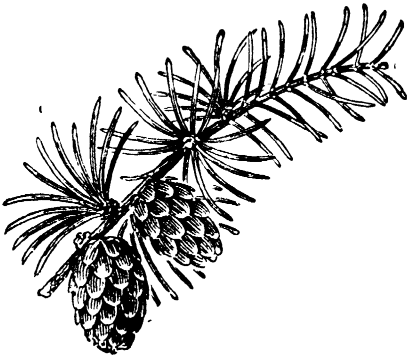


FIG. 79.—LEAVES AND FRUIT OF PINE.

8. *The Polar Snow Deserts.*—The two Frigid zones are the spaces between the Arctic and Antarctic Circles and the Poles. Here there is perpetual ice and snow, for the heat of the sun, in the short summer, is not enough to melt them. Round the North Pole there is a sea covered by floating ice. The South Pole is a lofty plateau covered by thick layers of ice. To it the name of *Antarctica* has been given. The countries in the Arctic Ocean are Greenland and the islands of Nova Zembla and Spitzbergen. A few Eskimo live on the western border of Greenland, where the climate is not so cold as it is elsewhere. Like the Lapps, they live by fishing and hunting the wild animals of the Arctic regions, such as the seal and the whale, and on the milk and flesh of the reindeer, which they have tamed.

Mountain Belts of Vegetation.—As there are belts or zones of vegetation, following the zones of sunlight and sun-heat, from the Equator to the Poles, so, too, we find very similar zones of vegetation in ascending ranges of lofty hills. Precisely the same changes of temperature occur (as we saw in Lesson 25) from the Equator to the Poles as from the sea-level to a great height in the air. The same kinds of plants are found on the summits of lofty mountains as in the Polar regions, namely, mosses and stunted shrubs. In the Himalayas, for example, tropical trees grow at the base of the mountains; such plants as are found only in Warm Temperate regions grow on the lower slopes; then follow the plants of the Cool Temperate zone and, above these, there is the vegetation of the Cold zone.

EXERCISES.

1. What is meant by the "habitat" of a plant or animal?
2. Name some animals that are found in temperate forests.
3. How may the different lands on the earth's surface be classified in accordance with their flora or vegetation?
4. What conditions are—(*a*) favourable, (*b*) unfavourable, to animal and vegetable life?
5. Explain how it is that the animal—man—contrives to live in so many regions of the earth. What regions are absolutely uninhabitable? What regions are—(*a*) most densely, (*b*) most sparsely, populated?
6. In what parts of the world do we find the largest and strongest animals, the highest trees, and the most luxuriant vegetation?
7. Describe and give instances of—(*a*) deciduous, (*b*) coniferous, (*c*) evergreen, trees.
8. Describe the flora and fauna of—(*a*) the Arctic regions, (*b*) the tundras, (*c*) the steppes, (*d*) deserts, (*e*) monsoon lands.
9. In what latitudes do we find as a rule—(*a*) pine forests, (*b*) deciduous forests.
10. Describe the selvas. Why are they so called?
11. Name the animals whose proper home is in the Tropics.
12. How is it that Europe, once covered with dense forests, is now grass-land, wood-land, and cultivated land?

27. POPULATION OF THE WORLD.

TOWNS.

THERE are supposed to be about 1600 millions of people in the world. Once in every ten years there is a census or counting of the people in the British Empire and in most civilised countries. But in many other countries there is no such census, and the population is, more or less, a guess.

More people live in some countries than in others. Men crowd together in the fertile and well-watered parts of the earth, and in regions where the climate is pleasant and healthy. The rich lands in the basins of the Ganges, the Yangtze Kiang, and the Nile—India, China, and Egypt—have a dense population. So have the British Isles and parts of Europe and North America. In these parts of the world the climate is good, and there are great stores of coal and iron which make it easy to manufacture goods. In countries like these, people crowd together in large towns, where there are factories and workshops.

The *Density of Population* in the world is shown in Map 2 (coloured). The most thickly populated tracts are coloured dark brown. They include the countries just mentioned. Other shades of brown show less thickly-peopled countries. The deserts, where no one lives, are in white. The countries coloured yellow are very thinly inhabited, either because they are arid half-desert lands, or because they are very hot and damp and covered with dense forests, like the selvas in the basin of the Amazon in South America.

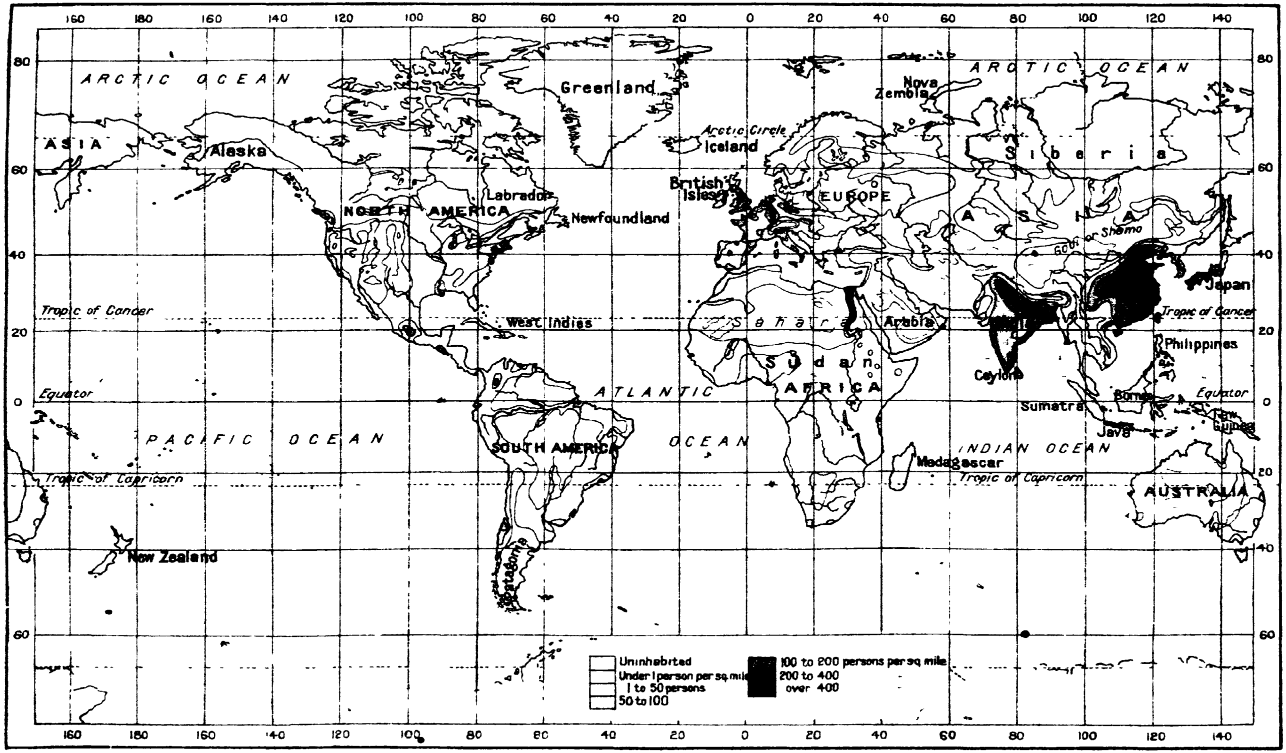
Towns grow up in different ways and for different reasons. They are, as a rule, at first villages, which gradually get larger and end in being cities. All men were at first hunters or fishers, and they moved about from place to place. When men began to cultivate fields they had to stay in one place, and they built their huts closely together so that they might be able to help one another in time of need. As time went on, the villagers often built a wall round their village to protect it from attack by other tribes. This was the beginning of a walled city. As water was always wanted, villages were often built on the banks of a river. Fishermen also lived in villages on the banks of rivers or on the shores of the sea.

Thus we find the following classes of towns in different countries:

1. *Agricultural Towns.*—These are in the middle of cultivated land. They are small in size, and in civilised countries have a few craftsmen; such as blacksmiths, tailors, and carpenters,

DENSITY OF POPULATION

2



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and small tradesmen who supply the farmers with goods, often in exchange for their produce. The buildings, besides dwelling-houses and shops, are usually an inn, a post office, a school, a church, and perhaps a railway station, *e.g.* **Chelmsford, Norwich.**

A *market town* is in the centre of a number of villages. It is, as a rule, the meeting-place of several roads. Here the farmers come from the country for miles around, to sell their produce, and to take back, in their carts, the goods they need.

A *manufacturing town* is full of factories and workshops, and usually grows up in the centre of a small region where some vegetable or mineral product is produced or can be imported easily. Where flax grows, there linen manufacturers will flourish and a town will be built, *e.g.* **Belfast** in Ireland. Where there is good clay, potteries will be built, *e.g.* in **Stoke-on-Trent** in England. Where wool is abundant, there will be towns for the manufacture of woollen goods, *e.g.* **Leeds** and **Manchester** in England. Where there are coal and iron mines close by, there will be large towns with factories for the manufacture of iron and steel goods, *e.g.* **Birmingham** and **Sheffield** in England. Belgium is full of towns like this, *e.g.* **Liége** and **Antwerp.**

River towns grow up on the banks of rivers, for before railways were built rivers formed waterways on which goods could be carried everywhere. Often such towns grew up at the confluence of two rivers, *e.g.* **Reading.** Other towns arose near the mouth of a river up which the tide came, for boats could come up from the sea with the tide. They may be called *Tidal towns*, *e.g.* **Perth, Limerick.**

Bridge towns grow up where a river can be crossed by a ford or ferry, and then later on by a bridge, *e.g.* **Cambridge, Weybridge.**

Gap towns were often built, in the old days, in a gap or narrow passage between a range of mountains and the sea. Such a town would command the roads from both sides. A castle or fort was often built in a gap like this, to keep off enemies, *e.g.* **Guildford.**

Nodal towns are such as are built at a *node* (Latin *nodus*, a knot), *i.e.*, a centre where many roads or railways cross. Good instances of nodal towns are **Carlisle** and **Shrewsbury.**

Out-ports are seaport towns on an estuary or bay below a great seaport, which take a part of the traffic, chiefly passengers or light goods, which are then conveyed very rapidly by rail to the main port or to other inland towns, while the heavier and more bulky goods go slowly up the river or bay. **Tilbury** is an out-port of London, **Avonmouth** of Bristol.

An *Entrepôt* is a port to which goods are brought and stored and then sent away to other countries. Nearly half the goods exported from **London** are re-exports of goods which were imported and stored there. They came from other countries and go back to other countries. London can do this because of its central position. It is a vast entrepôt.

Strait towns are built on straits for the same reason that gap towns are built in narrow gaps. They command the passage through a strait. There is always a strong fort in a strait town, with heavy guns which could sink the vessel of an enemy attempting to pass through. **Gibraltar** commands the entrance to the Mediterranean Sea. **Constantinople** commands the sea route from the Mediterranean to the Black Sea.

Mining towns soon spring up where there are large mines, especially gold, iron, or coal, *e.g.* **Swansea** in Wales (coal mines), **Johannesburg** in South Africa (gold mines).

Sacred Places.—Here, too, towns gradually arise around some shrine or ancient temple or on a sacred river, *e.g.* **Mecca**, in Arabia, the sacred city of Mohammedans; **Jerusalem**, the holy city of the Jews and Christians.

Hill-stations or *Sanitaria* in India and *Watering-places* in England are similar, for people go to them for a time to escape the heat or to bathe in the sea. Nearly every province in India has its hill-station, *e.g.* **Simla.** There are watering-places all along the coast in England, *e.g.* **Brighton** on the south coast and **Scarborough** on the east coast. **Bath, Cheltenham, Harrogate, Buxton,** are noted for mineral springs.

The table below shows the fourteen largest cities in the world. All have over a million of inhabitants.

City.	Population [1]	Country.
London (Greater London)	7,250,000	England
New York	5,300,000	United States
Paris	2,890,000	France
Chicago	2,500,000	United States
Tokyo	2,500,000	Japan
Petrograd	2,320,000	Russia
Vienna	2,150,000	Austria
Berlin	2,070,000	Germany
Moscow	1,800,000	Russia
Philadelphia	1,760,000	United States
Buenos Aires	1,640,000	Argentina
Osaka	1,460,000	Japan
Calcutta (and suburbs)	1,222,000	India
Constantinople	1,200,000	Turkey

EXERCISES.

1. In what ways and for what reasons do towns grow up in certain places?
2. Describe and give instances of: Agricultural towns, market towns, manufacturing towns.
3. Give examples of river towns and bridge towns in the British Isles.
4. What is a gap town? Give one or two instances.
5. Why are nodal towns so called? Give one or two examples.
6. Distinguish between a port and an out-port, with instances.
7. Sometimes a town springs up in a sacred place. Give an instance of such a town—Christian, Mohammedan, and Hindu. Say why each is held sacred.
8. What is—(*a*) a sanitarium, (*b*) a watering-place? Give instances.
9. What is the largest town—(*a*) in the world, (*b*) in America, (*c*) in Asia?

28. THE RACES OF MANKIND.

THERE are many nations and tribes of men, and at first sight they seem to differ from one another in every way—in colour and height, in habits and customs, in language and religion, in the food they eat and in the dress they wear, in body and in mind. Here, for example, are two men, one of whom is a native of Patagonia in South America. He is about 6 feet 4 inches high. The Patagonians are the tallest race in the world. The other belongs to one of the shortest races in the world, the Bushmen of South Africa. He is 4 feet 6 inches high. What two men could look more unlike than these?

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[1] Figures from the *Statesman's Year-Book, 1920.*

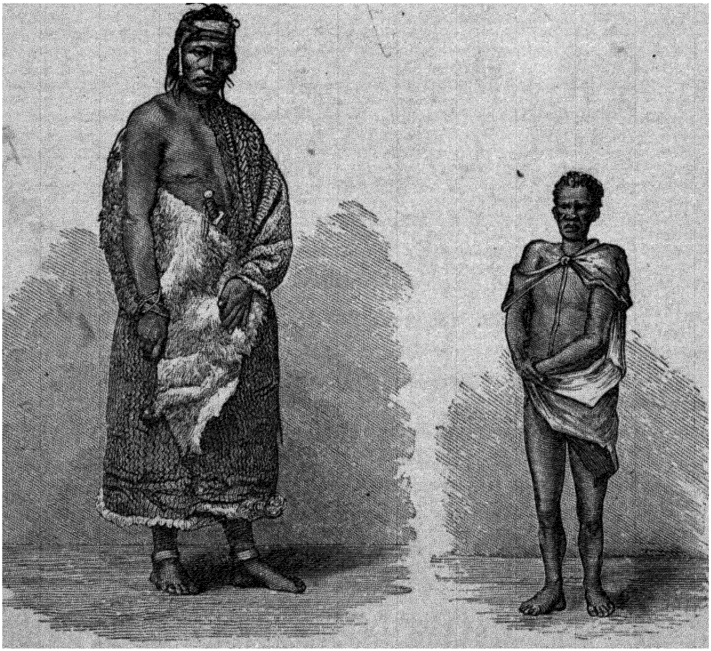
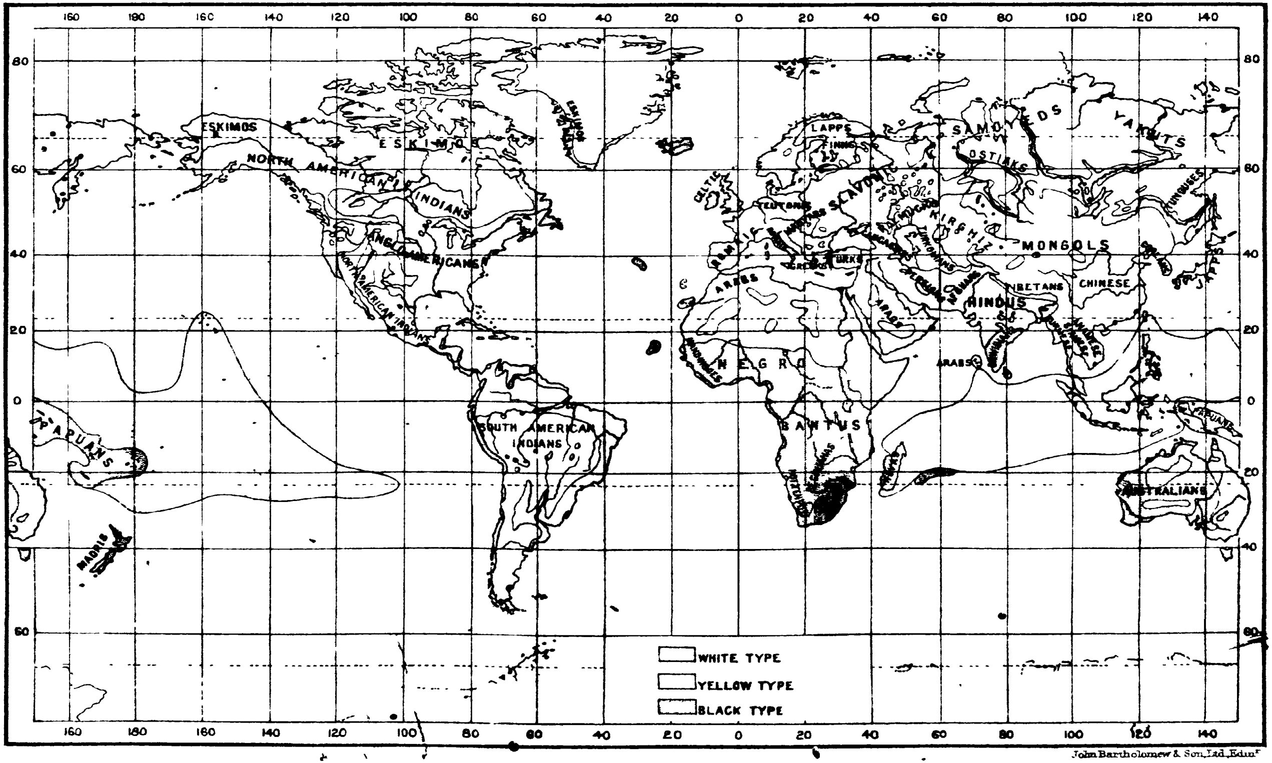


FIG. 80.—PATAGONIAN AND BUSHMAN.

Yet, when we examine men in different countries very carefully, we find that we may divide them all into three classes or races. Each of these races differs from the others in three or four ways, while all the men of one race resemble one another in these points. There are a great many subdivisions of these classes caused by intermarriages, by climate, by food, and by habits of life. But we find, among them all, three *types* of men, and all those of the same class are more or less like the type.

RACES OF MANKIND

3



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The three classes are based, first of all, on *colour.* The classes are:

1. White men or *Caucasians.*
2. Yellow men or *Mongolians.*
3. Black men or *Negroes.*

There are two subdivisions of Mongolians:

4. Brown men or *Polynesians.*
5. Red men or *American Indians.*

The other race marks are in the size and shape of the skull, the hair, the jaws, and the mouth.

The Hair.—The hairs on a man's head look as thin as a thread. But they are really hollow tubes. If a hair be cut across and the end looked at through a microscope, it will be seen that it is more or less round, like the edge of a tube. In Fig. 81 there are the cut ends of four hairs: *a*, that of a Mongolian, is quite round; *b*, that of a Caucasian, is oval; *c*, that of a Negro, is a very long oval; *d*, that of a Papuan, is a still longer oval. The Papuan is a subdivision of the Negro. He lives in the islands of the Pacific about New Guinea. There is another way in which the hairs of these classes differ. The hair of the Negro is thick, black, and woolly, like the wool on a sheep. That of the Caucasian is wavy or curly. That of the Mongolian hangs straight down, it has no twist or curl in it.

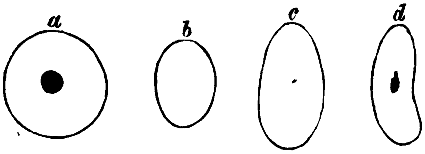


FIG. 81.—SECTION OF HAIR OF MONGOLIAN, CAUCASIAN, NEGRO, PAPUAN.

The *Skull* of the Mongolian is broad and round like his face. He is said to be "broad-headed." The Negro has a long skull and is "long-headed." The skull of the Caucasian is, in shape, between these. He is said to be "middle-headed."

The Face.—The Caucasian has an oval face with a high nose, and his lower jaw is nearly in a straight line with the rest of his face. His eyes are in a straight line. He often wears a thick beard, and has to shave if he prefers to have a smooth face.

The Mongolian has a broad face and a broad nose, and slanting almond-shaped eyes with drooping lids. He has high cheek-bones. The hair on his face is scanty. He never has a beard, for he cannot grow one.

FIG. 82.
MONGOLIAN CHINESE.

The Negro has large round eyes, a flat nose, very thick lips, and his jaws project beyond the line of the face.

The distinctive race-marks of the Negro and Caucasian (Persian) are clearly shown in Fig. 83—the hair, the jaw, the nose, and the mouth. Add to these that the Negro is black and the Persian white or fair.

The Caucasians are so named because they were formerly supposed to have come at first from the country close to Mount Caucasus, where fine types of the race are still found. There are dark Caucasians and fair Caucasians. The Hindus, whose higher castes belong to this race, were once fair, but have become dark or brown from long residence in a hot climate. The people of North Europe, particularly the Scandinavians, are very fair with blue eyes, while those of South Europe, *e.g.* the Spaniards and Italians, are, as a rule, dark.

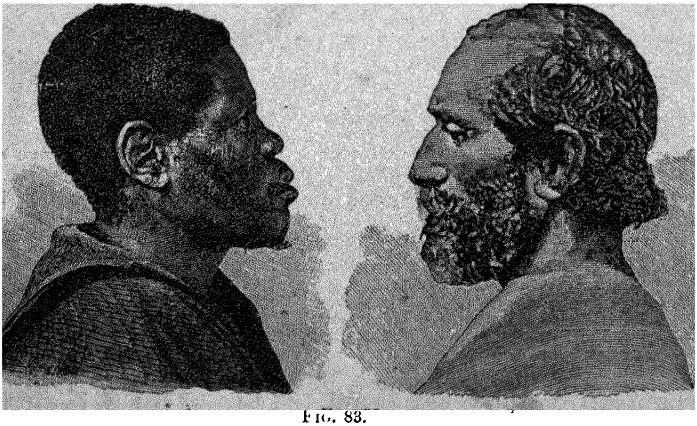


FIG. 83.

A NEGRO. A CAUCASIAN (PERSIAN)

There are about 750 millions of Caucasians, 650 millions of Mongolians, and 200 millions of Negroes.

The red men of the world are the native American Indians. They are a fine-looking race, tall and manly with high noses. North America was once inhabited by many tribes of red men, but very few are now left and they seem to be dying out. Their chiefs were fond of wearing feathers on their heads as in Fig. 84. Their red colour was a dark red, like dull copper. They are supposed to have been an offshoot of the Mongolian race, and to have entered America by crossing Bering Straits from Asia.

The distribution of the three great races of mankind, and the countries they now inhabit, are shown in Map 3. The light streaks of black in the Southern States of America show that although the country is inhabited mainly by white men, there are a good many Negroes there—once slaves, now free. Similar marks in South America show that American Indians are mixed with the descendants of the Spaniards and Portuguese who conquered and now inhabit the country.

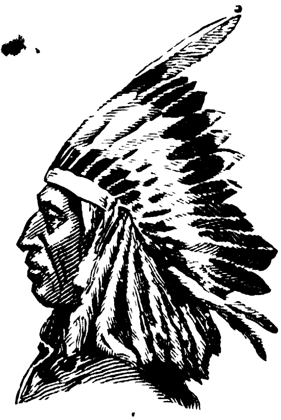


FIG. 84.
NORTH AMERICAN INDIAN.

EXERCISES.

1. Name the three great races of men. In what countries are they now found?
2. Describe the features of—(*a*) a Caucasian, (*b*) a Mongolian, (*c*) a Negro.
3. To what race does an Englishman belong?

29. MAPS AND MAP MAKING.

As the earth is a sphere, the best map of the world that can be made is one drawn on the outside of a ball, such as you may see on a "terrestrial globe."

But the surface of the earth is not flat. It is a curve, and a curved surface cannot be shown exactly on flat paper. A map that is perfectly correct cannot be drawn on a flat surface, but one can be made that is *nearly* correct.

The parallels of latitude and meridians of longitude, which cross one another on a globe (see Fig. 11), enable us to fix the exact position of a place. In making a map, the first thing we have to do is to transfer these cross lines to paper. This transference is called *projection*, which means "throwing forwards"—as a shadow is thrown forwards or projected on the ground by a man standing with the sun behind him.

Imagine that you have a large hollow glass globe, with the cross lines marked in black on the outside, and that there is a bright lamp inside, in the middle of the globe. Imagine also that there is a sheet of paper held upright, outside the globe, close to it. The black cross lines of the globe would cast their shadows on the sheet of paper. They would be projections of the lines.

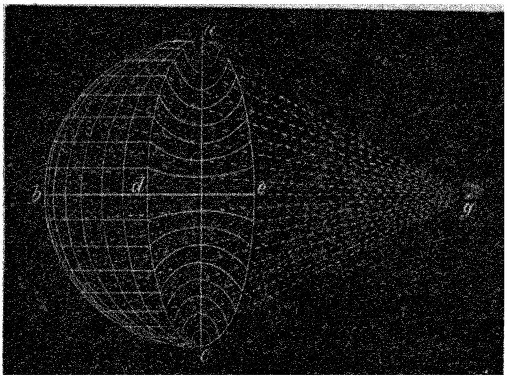


Fig. 85.—Globular Projection.

This is the principle on which maps of the world in hemispheres or half-globes are drawn. One method is known as *globular projection.* In the hollow hemisphere or half-globe (Fig. 85), *abc* shows the outside curved line on which the parallels of latitude are marked. You are supposed to be looking at it from the other side, and your eye is at the point *g*. The space *adce* is the opening of the half-globe, into which you are looking. It is termed "the plane of projection." The parallels are shown as they would appear to your eye when looking at the inside, or concave part, of the globe. The meridians are not put in, as the lines would crowd the figure too much. Fig. 11 in this book shows both parallels and meridians drawn on the plane of projection. Maps drawn on this globular projection show the sizes of the continents and their shapes fairly well.

Cylindrical Projections.—Sailors find another kind of map very useful. It is called the *Mercator* map, after a man of this name who invented it in the year 1569. The projection on which it is made is known as the Mercator projection (see Map 5). On this map the sizes of countries are much larger than they ought to be, as we go northwards. Greenland, *e.g.*, looks as large as Africa, but Greenland measures only 1400 miles from north to south, while Africa measures 4000 miles and is therefore about three times as long. Take your foot-rule and measure the distance from the equator to parallel marked 15°. Then measure the distance from parallel 60° N. to 75° N. You will find that the distance between the two latter lines is about three times that of the former, although both are only 15°.

The Mercator map is drawn on what is called a *cylindrical projection*, because the lines are projected on a cylinder. In Fig. 86 the glass globe is supposed to be enclosed in a cylinder or hollow roll of paper. Here the globe *enrs*, with the parallels and meridians marked on it, is enclosed in a roll of paper *abcd*. Suppose that there is a bright light placed in the centre of the globe, then it will project the shadows of these lines on to the paper, looking as you see them in the figure; those close to the light being closer together than those higher up; *e.g.* the distance from 10° to 20° (*i.e.* ten degrees) is much shorter than the same distance (of ten degrees) from parallel 50° to 60° and still shorter than the distance 70° to 80°. The shadows spread out wider and wider as they go more and more to the north. The

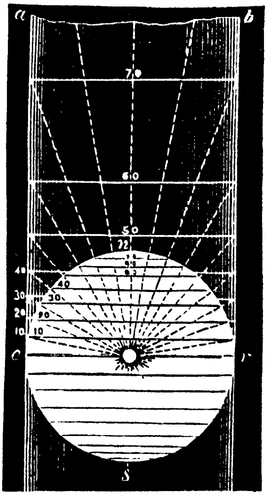


Fig. 86.—Cylindrical Projection.

meridians appear as parallel lines at equal distances from each other; hence they do not meet at the Poles and the polar regions cannot be properly represented on this projection.

The great advantage of a cylindrical projection is that the whole world can be shown on one sheet, and, in the case of the Mercator map, true bearings can be shown by means of straight lines. Distances, however, cannot be measured accurately.

The whole world can also be drawn on one sheet in projections known as *equivalent* or *equal area*, *e.g.* Sanson-Flamsteed's and Mollweide's maps are examples of such projections. The lines of latitude are drawn as parallels, the meridians meet at the Poles, areas on the map are equal to the corresponding areas on the globe, but the shapes of the continents are distorted especially near the margins of the map.

Conical Projections.—For small areas some form of conical projection is usually adopted. From the diagram it will be seen that with a light at the centre of the globe, the lines of latitude and longitude are projected on to the surface of the cone. If the cone be then unfolded, a network of lines will result as shown in the figure. It will be noticed that the cone touched the globe at latitude 45°. Hence near latitude 45° the map will be correct, and for some distance on either side of that line the map will differ slightly from the outline on the globe.

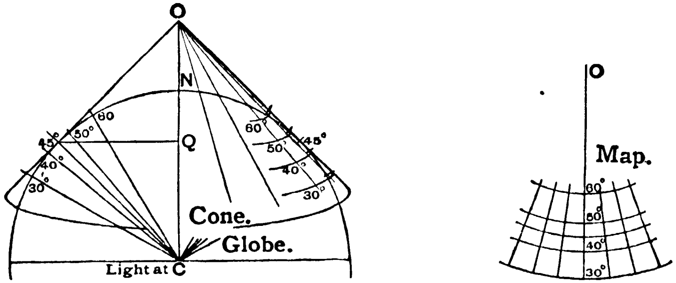


FIG. 87.—CONICAL PROJECTION

A modification of this projection is to make a cone cut the globe along two lines instead of touching the surface, *e.g.* the lines from O (Fig. 87) might be drawn through the points on the globe marked 60 and 30. In this projection, then, the map will be correct near the two lines 60° and 30°, while between them there will be little distortion.

Relief.—The *relief*, *i.e.* the different levels of the land—the heights, the mountains, and the hills—are shown in maps in different ways. In this book one way in which relief is shown is by colour. In Map 6 (of India), *e.g.*, eight shades of colour show eight levels of land from the sea-level to 18,000 feet and above. The depths of the ocean are in some maps shown in tints of blue. In Map 6, *e.g.*, the light blue shows the depth of 100 fathoms (= 600 feet); the dark blue shows deeper water Heights are often shown in maps by *contour* or *hachures.*

Contours are lines which mark the same level all over the ground.

In Fig. 87*a* the heights from 0 to 3000 feet are shown by the dotted *contour* lines below. On the map the land rises from 0 or the sea-level to A′, or 1000 feet; then to B′, or 2000 feet; then to C′, or 3000 feet. Here the distance between two contour lines is 1000 feet. But the distance may be any number of feet. The closer the lines are to one another, the steeper is the land. Fig. 88 shows a part of South India in which the levels are shown by contour lines. Up to the height of 1000 feet the rise from one line to another is 50 feet. Above 1000 feet the rise is 500 feet between the lines. You see how wide apart the lines are in the

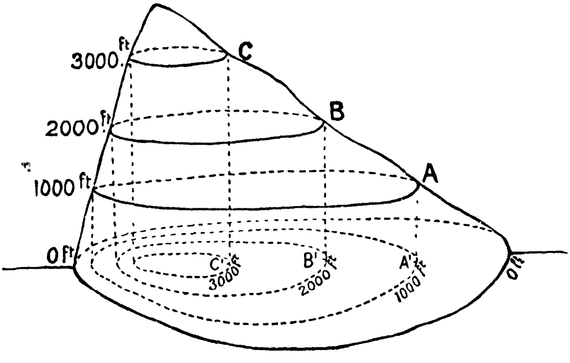
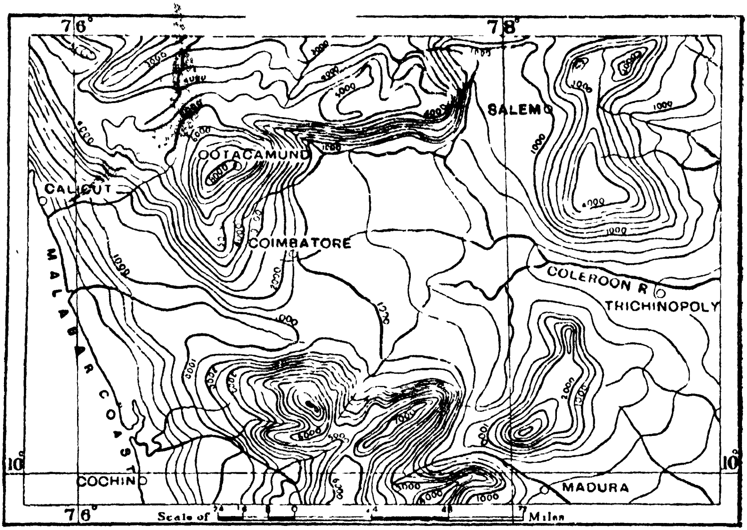


FIG. 87*a*.—HOW CONTOURS SHOW RELIEF.



Note *The Contours below 1000 Ft have been calculated at 200 Ft apart taking the Coast line at 0 and those above at intervals of 500 Ft*

FIG. 88.—RELIEF SHOWN BY CONTOURS.

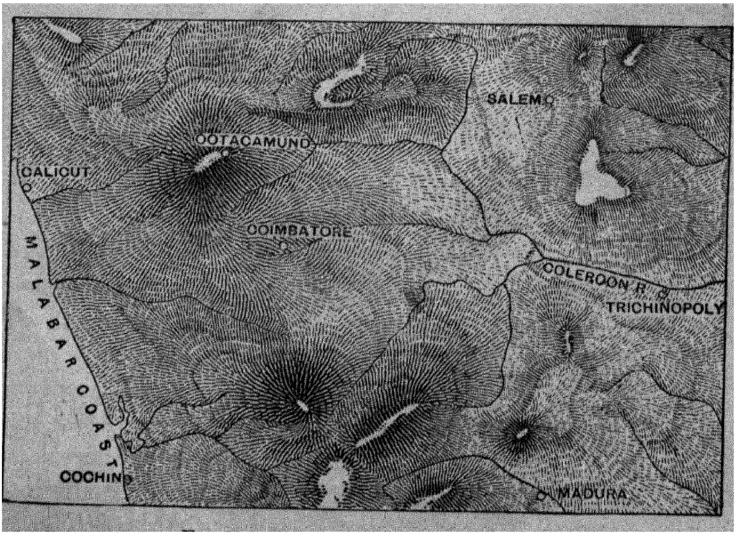


FIG. 89.—HOW HACHURES SHOW RELIEF.

PART II.—THE CONTINENT OF EUROPE.

30. EUROPE.

GENERAL DESCRIPTION.

EUROPE is naturally divided into two parts, each very different from the other. Eastern Europe, *i.e.* Russia, is a continental plain. Western Europe is a land of peninsulas.

The coast-line of Europe is therefore longer, in proportion to its size, than that of any other continent. Seas or bays or gulfs run up far into the land. Many rivers flow down into these seas, making waterways into the heart of the continent. *Trade* from one part of Europe to another, and *commerce* with other lands, are more easily carried on than in any other part of the world.

This peninsular or insular shape of the western countries of Europe has been of enormous importance to the nations which inhabit them. The nearness of the sea has given to most of them a temperate climate; it has made many of them into merchants and sailors with large fleets of trading vessels and powerful navies; it has civilised them by the intercourse they have been able to hold with all parts of the world; it has enriched them by interchange of goods in trade and commerce; it has fed them from the fisheries in the seas which surround them. As a consequence, these nations are the richest and strongest in the world. They now rule or control most of the nations of the Old World, and the descendants of European races inhabit or rule all the countries in the New World. In a similar way, and for the same reasons, the insular position of Japan has made it one of the great powers of the world.

The "relief" of Europe, *i.e.* the different heights of the surface of the land, is clearly shown in the coloured physical map, No. 17. Looking at this map we see three different levels of the land; there are low plains (coloured green), higher plateaus (coloured yellow), and still higher hills and mountains (coloured brown), the highest being dark brown.

The great northern plain extends for nearly 2500 miles from the Bay of Biscay through Russia to the Ural Mountains.

The long blocks of ancient plateaus were once probably great mountain ranges. Most of them have been worn down by the weather—the action of ice, snow, hail, rain, running water, and wind, working on them age after age—to plateaus of very hard rock at different levels, as a rule below 500 feet in height.

The belts of higher hills and mountains which rise to the south of the plateau land from the Bay of Biscay to the Black Sea, and to the Caspian Sea beyond it, all belong to one system, to which the name *Alpine* has been given. The system includes the Pyrenees, the Alps (with Mont Blanc, 15,775 feet), the Carpathians, the Balkans, and the Caucasus (with Mount Elburz, 18,526 feet). The Apennines and the Dinaric Alps on both sides of the Adriatic Sea, and the Sierra Nevada in Spain, are offshoots from the same system of folded mountains.

The *Rivers* of peninsular Europe are divided by the great watershed of the continent—the highlands which extend from west to east—into those which flow north from those which flow south. The rivers of the Spanish peninsula flow westward. The great rivers of eastern Continental Europe, *i.e.* of Russia, rise, nearly all of them, in the Valdai Hills and flow southwards. The names of all these rivers, the countries which they water, and the seas into which they flow may be seen on Maps 17 and 18.

CLIMATE.

As nearly the whole of Europe lies within the Temperate Zone, the climate is, on the whole, temperate. The continent extends northward for about 2500 miles from the Mediterranean Sea, and therefore the countries in the south, those along the

Mediterranean Sea, lying in the *Warm* Temperate Zone, are warmer than the countries in higher latitudes in the *Cool* Temperate Zone.

There is another reason for the mild climate of the Mediterranean countries. Most of the great ranges of mountains, *e.g.* those of the Alpine system, run from west to east. They protect the countries lying south of them from cold northern winds. The Alps, *e.g.*, shelter Italy, as the Himalayas shelter the valley of the Ganges, from the icy blasts from the north. On the other hand, as few mountain ranges run from north to south, the western winds can blow far into the interior of the country between the ranges running from west to east. These westerly winds from the warm Atlantic Ocean bring warmth and moisture into the countries of Western Europe. As we go from west to east, away from the Atlantic Ocean, the climate is less and less maritime and more and more extreme, for the influence of the warm westerly breezes grows less and less. On the other hand, the great range of the Scandinavian mountains, running for 1000 miles from north to south, shuts out the warm Atlantic winds from the countries of Sweden and Lapland, which lie to the east, making these countries much colder than they would be if these mountains were not there.

As to the *rainfall*, it is heaviest on the mountain ranges along the western coasts of Great Britain, Norway, and Spain, and on the ranges of the Alpine system in Central and Southern Europe. It diminishes as we go eastward, and in the south-east of Russia it is less than 8 inches in the year. Thus there are, generally, three kinds of climate in Europe, viz.:

Marine climate in W. Europe; with small range of temperature, and most rain in autumn and winter.

Continental climate in Russia; with extremes, and often, summer rains.

Mediterranean climate; with winter rains.

Vegetation.—The zones of vegetation numbered 4 to 8 in Lesson 26 are all found in Europe. Below the region of ice and snow in the far north, in the Arctic Circle, come the *Tundras.* The extreme north of Russia, including Lapland, is Tundra land. The next zone is that of the *Conifers*—the Pine, the Fir, and Larch trees. Coniferous forests stretch right across Scandinavia and northern Russia, where the chief industry of the people is "lumbering," *i.e.* felling the trees, and floating the logs down the rivers to saw-mills where they are sawn into planks.

South of the Conifers is the zone of *Deciduous*[1] forests, which includes most of the countries of Central Europe. Here the trees are the Oak, the Birch, the Beech, the Ash, and the Elm. The leaves of these trees fall off in autumn, so that in winter the boughs are bare. Where the rainfall is very small, as in south-eastern Russia, trees cannot grow, and we find a region of *Steppes* to the north of the Caspian Sea. The Steppes are wide stretches of grass-land on which large flocks and herds of cattle graze. The chief occupation of the people of the Steppes is the rearing of cattle. They live in tents, and wander from place to place in search of good pasture-land. In some of the Russian steppes there is enough rain to grow large crops of wheat (which is merely a cultivated grass). In the countries along the Mediterranean Sea, many of the trees are *Evergreen*. The most valuable plants [illegible] this region are the Vine and the Olive, which are grown nearly everywhere. Drought-resisting trees, *e.g.* palm, cork, orange.

Products (vegetable).—The *Grains* most largely cultivated are Rye and Oats in the north, Wheat in Central and Southern Europe, and Maize in the Mediterranean region. *Beet*, from which sugar is made, is very widely cultivated in Central Europe. *Flax* is grown chiefly in Russia. *Timber* trees are grown chiefly in Sweden, Norway, Russia, and Austria-Hungary. *Fruit* trees are cultivated everywhere. Oranges and lemons, olives and figs, grow best in the Mediterranean countries. The *Potato* is very widely grown and used for food.

Products (animal).—*Wool* is produced chiefly in the British Isles, Russia, and Germany. *Silk* is a product of northern Italy and France. *Fishes* abound in the shallow parts of the North Sea and the Mediterranean, and are one of the chief sources of food in many European countries. *Butter*, *eggs*, and *cheese* are produced largely in Holland and Denmark.

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[1] Latin. *De* = from + *cad* = fall.

Manufactures.—The manufactures of any country depend chiefly on whether coal is found in it, particularly near iron. The countries which export manufactured goods most largely are Great Britain, France, Belgium, Germany, and Switzerland. In all these countries but Switzerland coal and iron are found.

Minerals are found in great abundance in Europe. In nearly every country there are mines of coal, iron, copper, lead, and salt. *Tin* is found in Great Britain, *Zinc* in Belgium and Germany, *Mercury* in Italy, Spain, and Austria-Hungary, *Sulphur* in Italy, *Iron* in north Spain, *Copper* in south Spain (Rio Tinto).

Animals.—Domesticated or tame animals are found in every country in Europe. Some of them are used for riding or for drawing carts or for ploughing, *e.g.* the horse, the ass, and the mule; some for milking, as the cow and the reindeer; some for food, including cattle, sheep, pigs, and poultry. Very few of the larger wild animals now exist in Europe, although in ancient times they abounded in the forests.

WILD ANIMALS.

The *Polar Bear*, also known as the White Bear, is one of the largest of the Bear tribe. It is 9 feet long and weighs from 800 to 900 pounds. Yet it is very active and can run faster than a man. It swims very well, and lives on fishes and porpoises and seals and walruses. It has a thick oily skin covered with fur, which keeps it from getting wet. Its home is a cave in the ice.

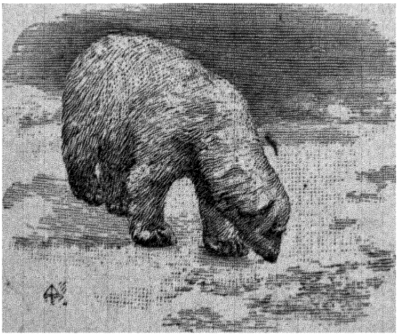


FIG. 90.—POLAR BEAR.

The Seal.—Seals are not fishes although they live chiefly in the sea, swimming and diving like fish. They are warm-blooded animals and suckle their young. They are covered with a thick oily skin through which water cannot pass, and over it they have a thick warm coat of fur. They have broad webbed feet with which they swim. They live in the ice and snow, and catch and eat fishes. Hunters kill a great many of them every year for their skins, which are very valuable.

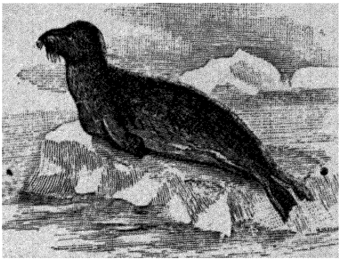


Fig. 91.—Seal.

The *Walrus* is one species of seal. It is not found outside the Arctic Ocean. It is a huge creature, being 12 or 13 feet in length, and weighs nearly a ton. It differs from all other seals in having two long powerful tusks. With them it digs in the ice and sandy mud for shell-fish; with their help it climbs over the ice; with them, too, it fights if attacked.

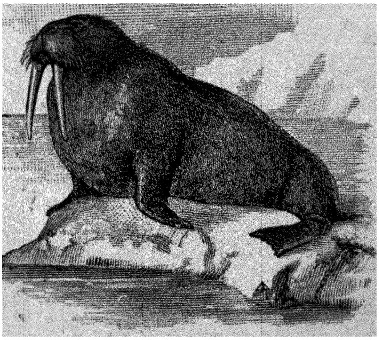


Fig. 92.—Walrus.

The *Arctic Fox* is smaller than the common fox, and in winter its coat of fur turns quite white, so that it cannot easily be seen on the snow. It feeds on sea-birds and their eggs, and anything else it can find. It has a soft white fur which is va[illegible] and many hunters in th[illegible]orth of Europe, Asia, and [illegible]rica are always busy catching foxes in traps or shooting them.

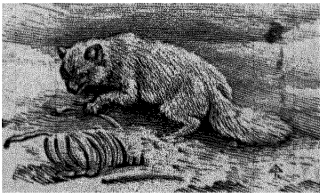


Fig. 93.—Arctic Fox.

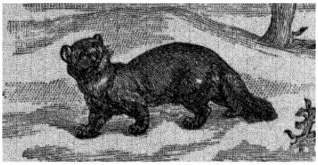


FIG. 94.—SABLE.

The *Sable* belongs to the same tribe as the Indian mungoose. It is found in the far north of Europe. It is about a foot and a half long, and has a beautiful coat of fur which in winter is quite white. It is also found in the far north of Asia and America. It lives in the trees, and is found only in some parts of the southern tundra where low trees are found. It lives on mice, small birds, and eggs. Sables are hunted for their furs.

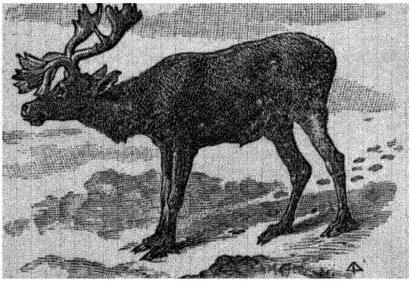


FIG. 95.—REINDEER.

The *Reindeer* is the only variety of the deer tribe which has been tamed and used by man. It is found in the north of Europe, Asia, and America. Without its help man could not live in those dreary regions. Large herds are kept, as cattle are kept in other countries. Reindeer live on moss, which they scrape out of the snow with their hoofs. The Laplanders and tribes of N. Siberia drink their milk, and travel about from place to place on sledges drawn by their deer.

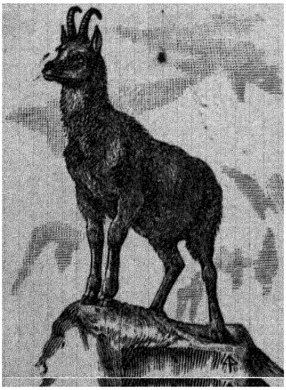


FIG. 96.—CHAMOIS

The *Chamois* is very much like the ibex of Asia. It is a little mountain antelope about two feet in height, and has short black horns. It is one of the most active of living animals, leaping from rock to rock and skipping up and down steep cliffs where no other animal can get a foothold. It lives in herds, on the Alps, an old buck always keeping watch on a high rock while the rest of the herd feed.

The *Brown Bear* is found chiefly in the low wooded hills of Russia and in parts of Central Europe. It goes about in pairs, not in herds. It feeds chiefly upon roots and fruit and wild honey, but will also eat flesh and sometimes catches and kills small animals. It can climb trees easily. In cold countries it goes to sleep all the winter, in a hole which it digs for itself in the ground.

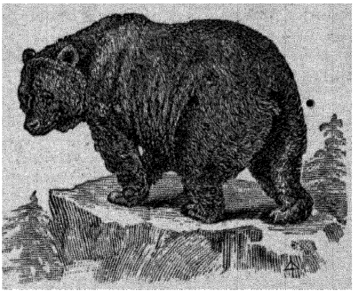


Fig. 97.—Brown Bear.

The *Wolf*, too, is found chiefly in Russia. Wolves go about in large packs, and in winter they get very fierce and bold, and hunt for men who may be travelling across the country, because there are no animals at that season to be found in the forest where they live. They are held in much dread by the Russian villagers.

Fig. 98.—Wolf.

Exercises.

1. Contrast the continent of Europe with the other great land masses as regards position, coastline, and relief.

2. Divide Europe into climatic regions, and state the features of each.

3. Describe—(*a*) the distribution of forests in Europe, and (*b*) the trees in the different forests.

4. Of what use to man are the following: Reindeer, walrus, seal, and sable?

31. THE BRITISH ISLES.

POSITION, RELIEF, PRODUCTIONS, TRADE.

WHEN we talk of the British Isles, we think chiefly of Great Britain—including England, Wales, Scotland—and Ireland. These are the two largest of a group of about 1500 islands. Nearly all of them, however, are tiny islets, uninhabited. The larger islands are:

The Hebrides, Orkney and Shetland Isles, north of Scotland.
The Isle of Man, in the Irish Sea.
Anglesea, off the north-western coast of Wales.
The Isle of Wight, off the southern coast of England.
The Channel Islands, in the English Channel.

The official name for the British Isles is the **United Kingdom of Great Britain and Ireland.**

The extreme south-western point of the Island, extending far into the Atlantic Ocean, the end of the land, is called Land's End. It once reached still farther out to sea, as the rocks, not yet washed away, show. In time they will disappear. On the farthest rock there is a lighthouse to warn ships away from the rocks. It is called Longships Lighthouse.

Great Britain is, in shape, like a triangle pointing northwards, with a base of about 330 miles. The *coast* of this large island is nowhere one long straight line. It is everywhere *broken* and irregular. All along the coast, the sea runs up into the land by many openings or long "arms," inlets, coves, and bays, so that no part of the island is 70 miles distant from the sea, most of it being much closer. The only other large island in the world, with a similar shape, is Japan. Compare the shape of Britain with that of India or Africa, where the coast is nearly everywhere one unbroken straight line. No country in the world (but Japan) is so well shaped as Great Britain is, both for inland trade and for commerce with other countries. The bays and wide mouths and estuaries of the rivers make numerous harbours all along the coast. In them, ships can lie safe and sheltered from stormy winds. Goods can be taken on board or landed safely and easily and cheaply, for the largest steamers can come close up to the banks.

The great highway of commerce is now the Atlantic Ocean. The most important trade route in the world lies across this ocean, between America and Europe, through the English Channel, which is, so to speak, the gateway from the Atlantic Ocean into the North Sea and the countries round it. The British Isles lie directly in this route, and they have, therefore, the best situation in the world for the Atlantic trade. This may be seen clearly in Map 5, which shows the chief trade routes in the British Empire.

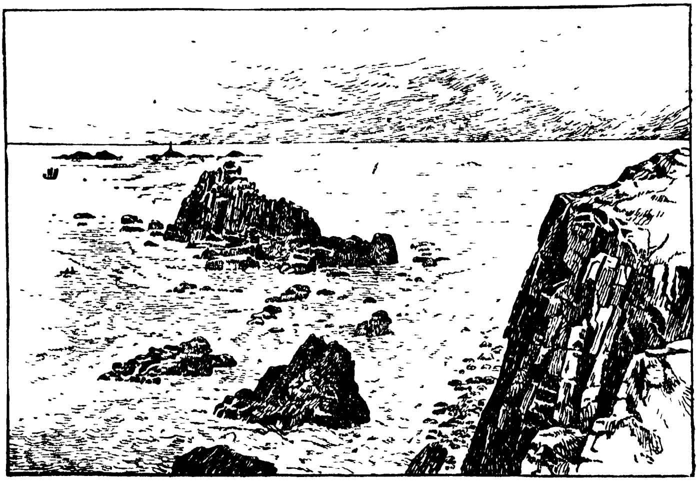


FIG. 99.—LAND'S END AND LONGSHIPS LIGHTHOUSE.

Moreover, a glance at the water and land hemispheres in Fig. 44 will show that London, the capital of the British Isles, is very nearly in the centre of the land hemisphere, including all the great countries of the world, except Australia. It is no wonder, therefore, that London is the largest and most important city in the world.

Great Britain is particularly well situated for trade with **Europe.** The mainland of the Continent lies opposite to it. Steamers from London can reach any of the ports on the coast of France, Holland, Belgium, Germany, or Denmark in a few hours.

Moreover, the long gentle slope of the land from west to east, which may be seen by the direction in which nearly all the rivers flow, is very favourable for trade with Europe. The mouths of these rivers open into the sea and form bays and harbours towards Europe, so that ships, large and small, can easily go to and fro between the east coast of England and the ports of Europe which lie opposite, across the North Sea. If the slope had been the other way, if the mountains of Great Britain and the scarp, or steep cliffs, had faced Europe, trade would not have been nearly so easy.

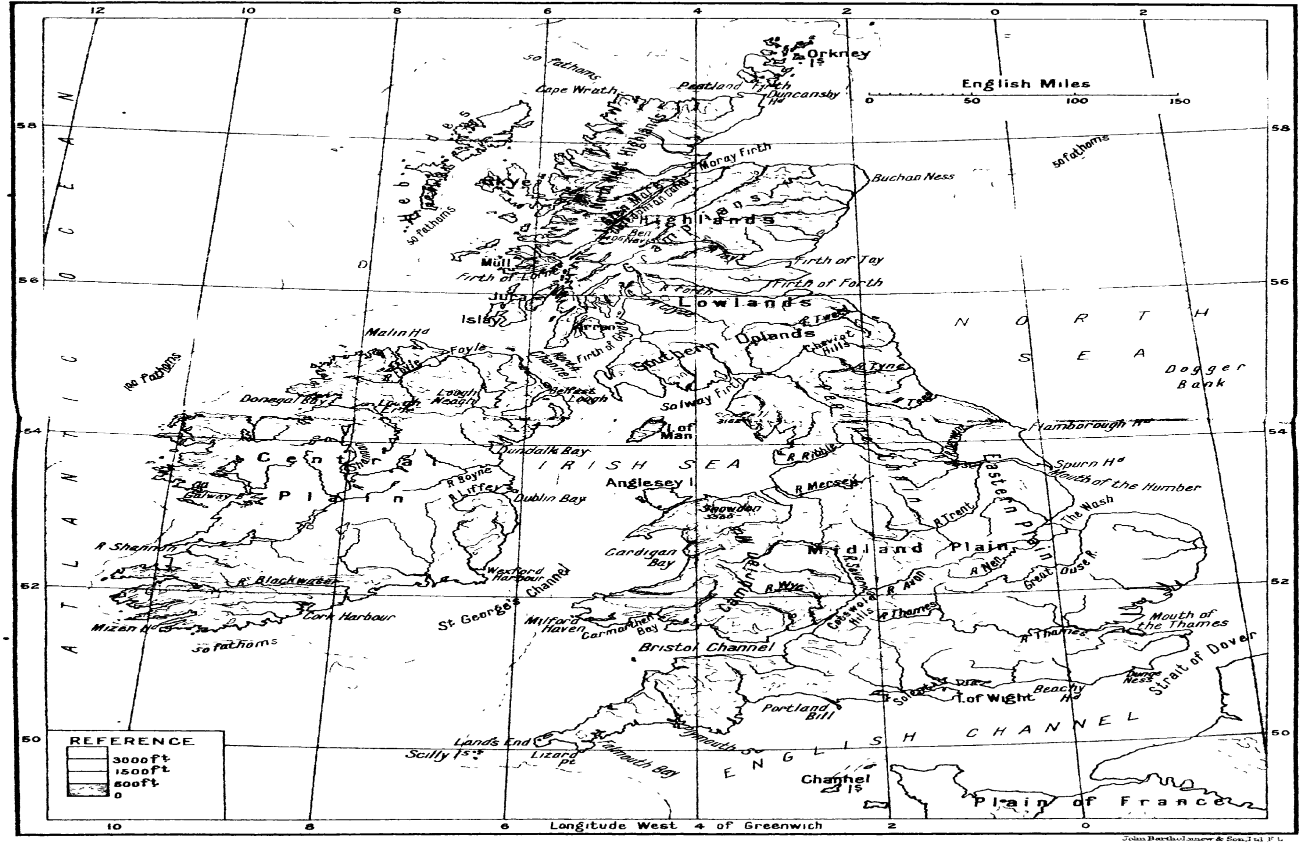
Also, the fact that Britain is an *island* with good ports and harbours all round the coast, makes trade with any country far easier than it could be, if it were, like Germany or Austria, in the middle of the Continent, with the sea on one small part only of its border. The carriage of goods by sea is much cheaper than carriage over land. And, as we have just seen, all the large manufacturing towns are within easy reach of some good seaport. For these reasons, the export of manufactured goods and the import of raw material and food costs comparatively little.

Map 4 shows, in colour, the physical features of the British Isles and the depths of the surrounding waters.

The light blue shows shallow water, the dark blue shows deep water. The British Isles are *Continental islands*, that is to say, they once formed a part of the Continent of Europe. *Oceanic islands*, such as those in the Pacific Ocean, never formed part of any continent.

The islands, of which Great Britain is one, rise from a tract of land a few hundreds of miles broad, which now lies below the level of the sea. It was once much higher than it now is, so that the Continent of Europe included it and stretched farther westward than it now does. This tract of land is called the

BRITISH ISLES—PHYSICAL



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Glen More (the Great Glen). The mountains in the northern half are the **North-West Highlands**; the southern are the **Grampian Highlands.** South of the Highlands there is a lower tract of land known as the **Central Lowlands.**

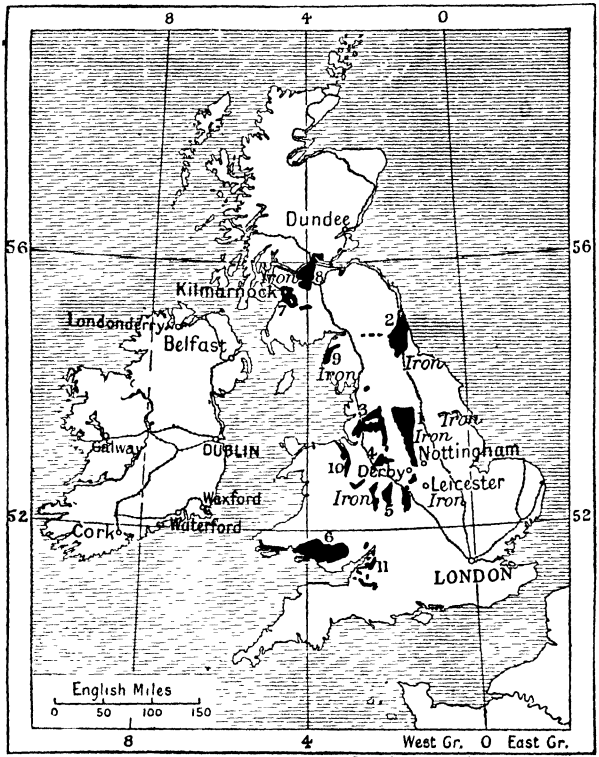
The *second* mountain mass is known as the **Southern Uplands.** They extend across Scotland from north-east to south-west, and stretch southwards into England where they are called the **Pennine Hills.**

The *third* great mountain mass is in Wales, and is known as the Cambrian or Welsh mountains.

The *Watershed* of the island is a ridge not far from the western coast. The escarpment or steep side is on the west, and the long gentle slope towards the east. The whole island was upheaved, millions of years ago, and rose, as a plateau or great solid mass of rock, above the level of the ocean. Then the rain, the frost, the winds, and the rivers did their work. All the softer parts of the rock were gradually worn away and washed down into the sea. The harder rocks still remain in ridges and blocks and peaks, and we call them mountains and highlands. Britain is therefore a *dissected plateau.* The highlands are not folded mountains like the Alps and Himalayas. The plains are still softer rock which was worn down to a lower level, and the hills upon them are made of chalk and limestone, which, though not so hard as granite, are harder than the sandstone and gravel and clay around them.

One set or system of rocks below the soil of England is more valuable than all the rest. It is the Carboniferous rock, *i.e. Coal.* Fig. 100 shows where the great coal-fields of Britain lie. They are coloured black. On this map are also marked the places where iron is found. The iron mines are nearly all close to the coal mines. The iron is worked up in factories where the engines are fed by coal. If the two minerals were at a distance from each other, as is the case in some countries, it would be necessary to take the coal to the iron mines or to carry the iron to the coal mines, and this carriage would cost a good deal. All the cost of carriage is saved when the coal and the iron are found close to each other, as they are in Great Britain.

Minerals.—Coal is by far the most important mineral of Britain. The industries of the whole country are based upon the coal which works the engines in every factory. Coal began to be used for machinery a little more than a hundred years ago, when



Stanford's Geog' Estab'. London

FIG. 100.—COAL- AND IRON-FIELDS OF GREAT BRITAIN.

steam engines were invented. Then came railways and steamers, which are run by coal. And in our days, coal gas is made and used for lighting and heating houses. In the year 1800, nearly 10,000,000 tons of coal were raised. This amount had risen in 1910 to 264,000,000. Most of the large towns in the country are found in the neighbourhood of the coal-fields. *Iron* is the next most important mineral. Then comes *Tin*, which is found in small quantities in the south-west of England. *Lead*, *Copper*, and *Zinc* are found in many places. But the needs of the British manufactories are so great that a great deal of all these metals is imported from abroad. *Slate* is quarried chiefly in Wales, and used largely for the roofs of houses.

Agriculture.—On the hard rocks which form the mountains the soil is poor, the air cold, and the winds are strong. Neither crops nor trees will grow, but on the slopes of the mountains there is always grass, on which flocks of sheep and cattle graze. The plains are, for the most part, fertile and highly cultivated. The chief grain crops are *oats*, *barley*, and *wheat*. But the population is so large that the grain is not nearly enough. Four-fifths of the wheat and flour used as food in Britain is imported from other countries, from Russia, Canada, the United States, India, Argentina, and Australia. The wheat-fields in England are all in the dry sunny plains of the south-east. Oats can grow in a cold damp climate. They are cultivated in Scotland and Ireland. *Turnips* and *potatoes* are other imported crops. Potatoes grow chiefly in Ireland.

TRADE AND COMMERCE.

The *Imports* are mainly of two kinds. Nearly half consists of food-stuffs, and more than one-third includes raw materials which are manufactured in England and exported as finished articles.

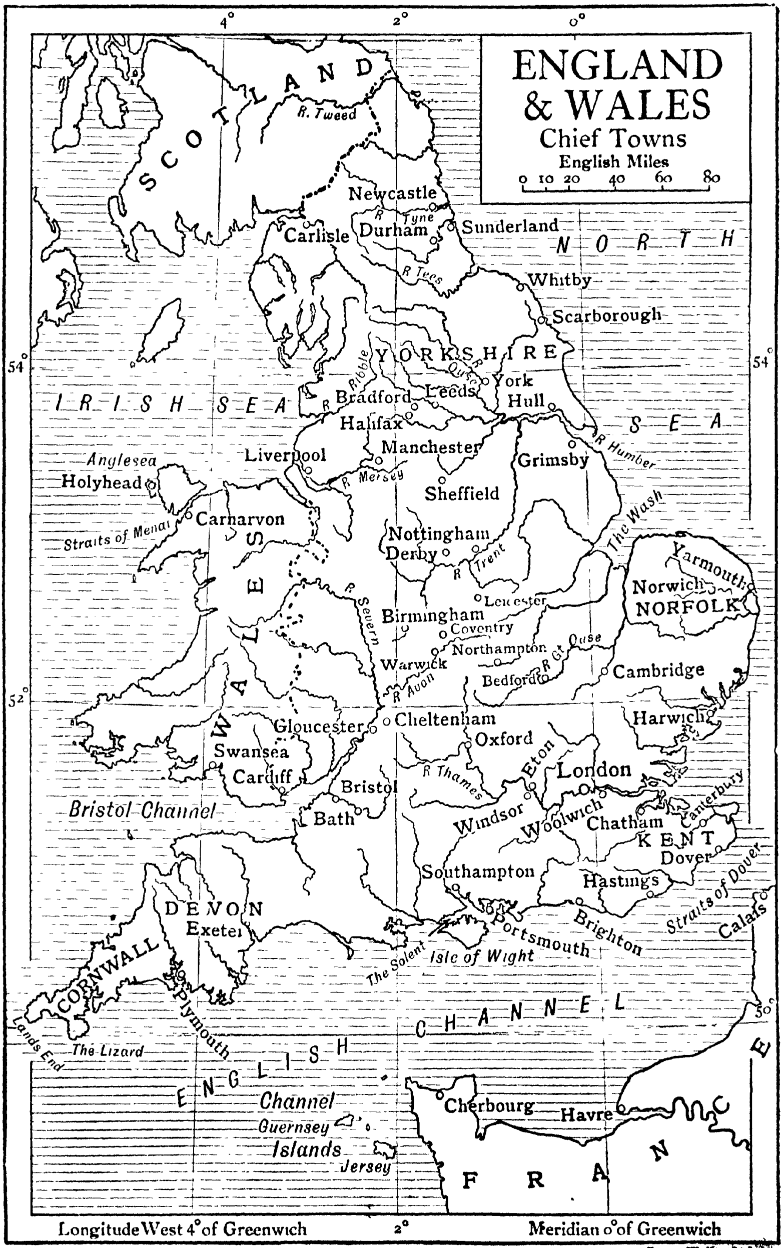
The *Food-stuffs* are grain (chiefly wheat) and flour, seeds, meat, sugar; butter, cheese and eggs (termed dairy produce), tea and coffee, fruits and wine.

The chief *raw materials* imported are raw cotton, wool, wood and timber, metals and ores, rubber, leather, hides and skins.

These imports come from all over the world, including the various countries within the British dominions, *e.g.* India, Canada, Australia, and Egypt; also from the United States, Germany, France, Russia, Argentina, Belgium, and Holland.

The *Exports* are nearly all manufactured goods and coal, and of the former, cotton goods far exceed all others.

The chief exports are: cotton, woollen, and linen "piece-



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goods"; iron and steel and machinery; coal and fuel; chemicals, wearing apparel, copper, jute goods, hardware, and cutlery.

The *Trade routes* followed by steamers are shown in Map 5. The distances are given in the map. Some of the chief routes, with their length in miles and the time usually occupied by ocean steamers, are:

London to	New York	3,000 miles	7 days
,,	Buenos Aires	6,100 ,,	22 ,,
,,	Cape Town	6,000 ,,	20 ,,
,,	Bombay	6,600 ,,	20 ,,
,,	Calcutta	8,200 ,,	33 ,,
,,	Yokohama	11,600 ,,	52 ,,
,,	Sydney	12,100 ,,	48 ,,
,,	New Zealand	13,000 ,,	46 ,,

New Zealand is the antipodes to London, so that going to New Zealand means going half round the world. The opening of the Panama Canal has shortened all voyages to places on the Pacific Ocean, especially on the west coast of America, enormously. Passengers and mails to India often save a week of the journey to Bombay by doing the first part of it overland by rail through France to Marseilles; they may save nearly two days more by going by rail to Brindisi in the south of Italy and there taking a steamer to Port Said, where they meet the mail steamer from London to Bombay.

EXERCISES.

1. Write an account of the Continental shelf off Western Europe.

2. Why are the British Isles so important commercially?

3. Compare the relief of Scotland with that of Ireland.

4. What are the two chief classes of Imports into England? Account for each.

5 Contrast the Exports with the Imports. Show that we could not do without either.

6. Why is there more fishing in the North Sea than in any of the other seas around Britain?

32. THE BRITISH ISLES (*continued*).

CLIMATE AND WEATHER.

CLIMATE.—It has already been explained[1] that the climate of the British Isles is determined chiefly by the seasonal changes due to the earth's movement round the sun and to the presence of a vast ocean to the west. In consequence of these conditions it should be noted that (*a*) the isotherms in January run from north to south, and show that the temperature on the west side, facing the Atlantic Ocean, is higher than that on the east side, facing the continent of Europe.

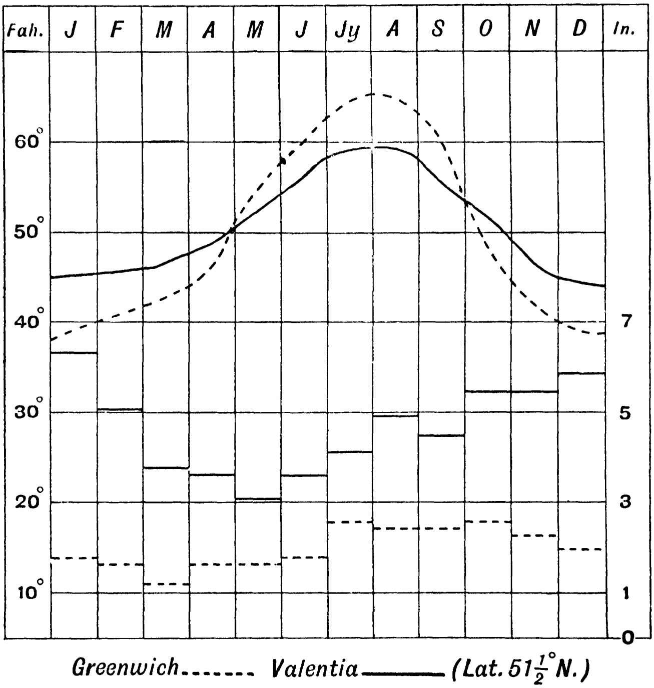

FIG. 101.—GREENWICH AND VALENTIA.

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[1] Cf. *Geography for Junior Classes*, Lessons 10, 14, 15, 16, 22.

(*b*) The isotherms in July run roughly from east to west, showing that the temperature decreases in a northerly direction. These isotherms, however, bend southwards when crossing the sea, the land now being hotter than the water.

(*c*) The west side of Great Britain has a heavier rainfall than the east, due to the prevailing S.W. winds and to the mountains on the west. In the case of Ireland the rainfall is more uniformly distributed, because of the mountains round the coast.

It has also been pointed out that these facts have been established from a series of observations extending over a long period of time. The climate, therefore, is the *average weather.* For example, the climate of Yarmouth, on the east coast of Great Britain, is drier than that of Aberystwyth, on the coast of Cardigan Bay, but on a particular day it might be raining heavily in Yarmouth and brilliantly fine in Aberystwyth. On that day then Yarmouth would have wet weather and Aberystwyth fine weather. If, however, the amount of rain be recorded for a year, or number of years, it will be found that the total rainfall of Aberystwyth far exceeds that of Yarmouth.

WEATHER. — The chief feature of English weather is its changeableness; this is due largely to the storms or cyclonic disturbances which pass over the British Isles. A cyclone is a movement of the air from high pressure to low pressure in a spiral direction; in the northern hemisphere this movement is opposite to that of the hands of a watch. [See Lesson 22.] On the weather chart (Fig. 102) isobars are drawn at intervals of one-tenth of an inch: the thick line (29·9 inches or 76·0 cm.) is the normal pressure, 29·8 to 29·1 being low pressure, 30·0 and 30·1 being high pressure. A cyclone is represented by the isobars on the chart with its centre off the north of Scotland. The air is moving round the area marked "low." By Buy Ballot's law, if you stand with the high pressure on your right and the low pressure on your left, the wind (in the northern hemisphere) will be blowing on your back, that is, in an anti-clockwise direction. From the isobars, then, the direction of the wind may be ascertained.

The isobars also show the strength of the wind; where the isobars are close together the wind will be very strong, where they are far apart the wind will be very gentle.

The broken lines on the chart are isotherms. The line marked 32° Fahr. (*i.e.* freezing-point) passes just south of Iceland and

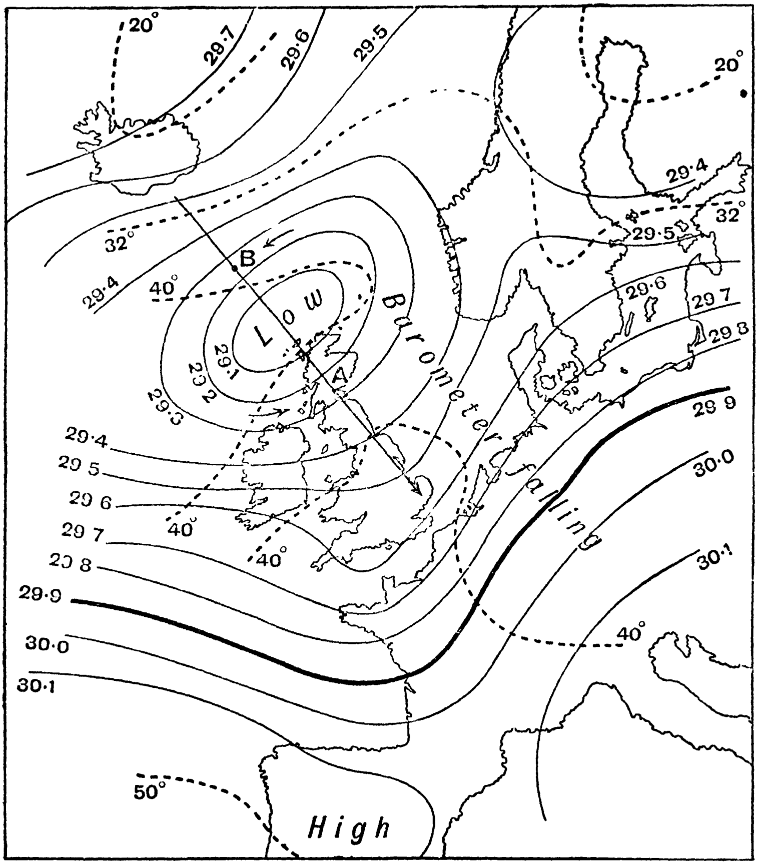

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Fig. 102.—Weather Chart, February 18.

across Scandinavia. In Iceland on that day a N.E. wind was blowing. The temperature was below freezing-point and very likely snow was falling. In South Wales at the same time a westerly wind was blowing, the temperature was higher than 40° Fahr. and probably rain was falling. In Central Spain, where the pressure and temperature were both high on that day, the conditions were anti-cyclonic and the weather would be fine.

Movement of a Cyclone.—The centre of a cyclone does not remain over the same place; while the air is moving round the low pressure area, the whole cyclone is moving onwards If the weather chart for the previous day could be examined, it would be found that the low-pressure area was near Iceland. Imagine, therefore, that the cyclone is moving in the direction indicated by the line BA, that is from Iceland towards Scotland and onwards in a south-easterly direction.

On the chart it will be seen that the part of the cyclone marked A is passing over Perth and the wind is W.S.W.; as the cyclone moves onward the part of the cyclone marked B will reach Perth and the wind will then be N.E. Hence the change of wind at Perth from W.S.W. to N.E. is due to the movement of the cyclone.

Similarly, other changes of weather may be found from the chart.

For more detailed information, reference must be made to the Daily Weather Charts issued by the Meteorological Office.

EXERCISES.

1. Explain clearly the difference between weather and climate.
2. From Fig. 102 describe the weather conditions at London, Stockholm, Cape Wrath, north-west Spain, north coast of Iceland.
3. How can the weather be forecasted?
4. State Buy Ballot's law, and explain it with reference to Fig. 102.

33. THE THAMES BASIN.

THE east and west sides of England and Wales may be contrasted in many ways. For example, the mountains of the west may be contrasted with the low-lying plains of the east; the warm wet climatic conditions of the west with the relatively cold dry conditions on the east. A man accustomed to the undulating plains and rounded hills in the south-east of England would, when

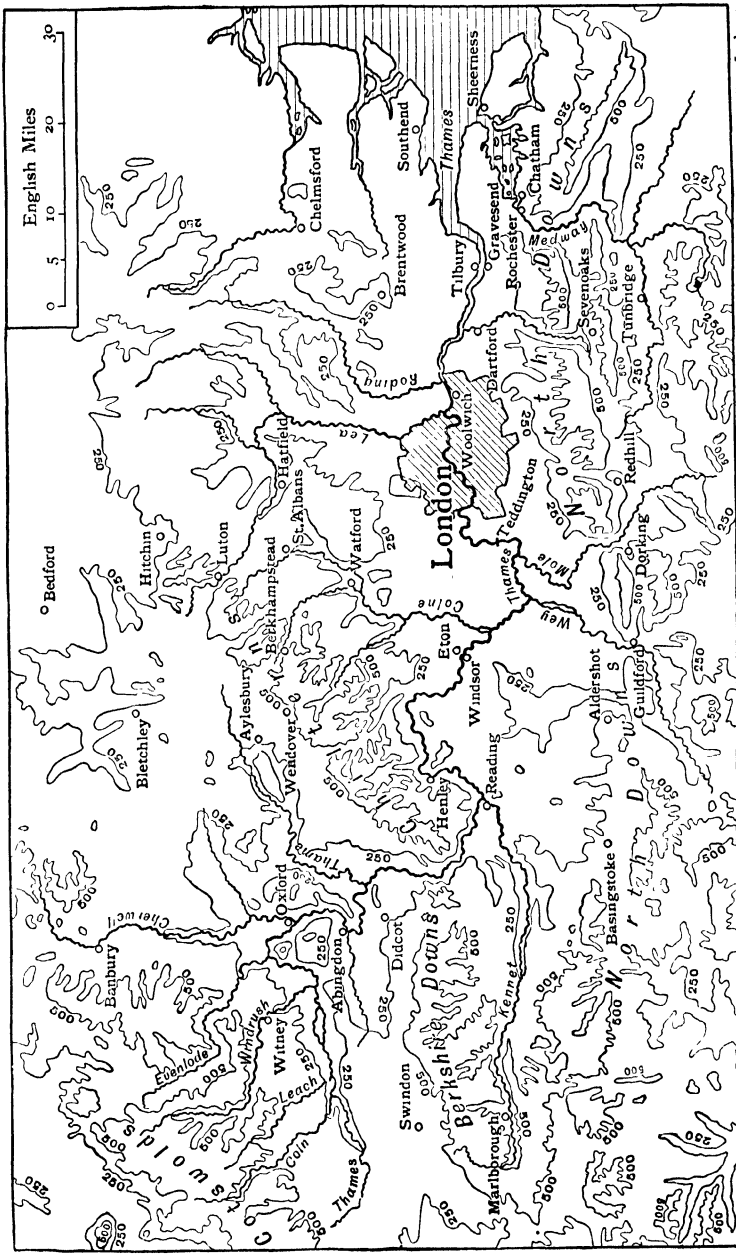

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FIG. 103 —CONTOUR MAP OF THAMES BASIN.

visiting the west, be much impressed by the grander scenery, the rugged mountain sides, the deep valleys with lakes and fast-flowing rivers.

The difference in scenery between west and east is largely due to the difference in rock formation. The mountains of Wales and Cumberland consist of hard formations such as Archaean (ancient) rocks and igneous (fire or volcanic) rocks. These rocks have been worn down by the action of ice (in the glacial period), frost, running water, and other agents. Weathering in this case goes on very slowly because of the hardness of the rocks.

The formations in the south-east are soft and are easily changed by weathering; they are all sedimentary rocks—that is, they were formed on the bed of a sea or lake by sediment which settled in layers on the bottom; such rocks are chalk, limestone, sand, and clay.

In the Thames Basin all these sedimentary rocks can be found.

The Isis, Colne, Windrush, and other streams which unite to form the Thames all rise in the Cotswolds, a range of limestone hills; after receiving the Evenlode, the Thames crosses the Oxford clay plain, passes through the chalk between the Chilterns and Marlborough Downs, and finally flows across the London clay to the North Sea.

Along the banks and at the mouth of the estuary the Thames is now depositing materials such as mud, sand, and gravel.

On comparing the geological map (Fig. 104) with the contour map (Fig. 103) it will be seen that—

(1) between the Cotswolds and the Chilterns a large area of the clay plain near Oxford is less than 250 feet in height;

(2) between the junctions of the Thame and Kennet the Thames flows through a gap in the hills; the contours show that the slope of the Chilterns from the Thames is much steeper than the slope of the Marlborough Downs;

(3) below Reading the valley broadens out into a wide plain;

(4) the tributaries Wey, Mole, and Medway also have cut gaps in the North Downs, a range of chalk hills.

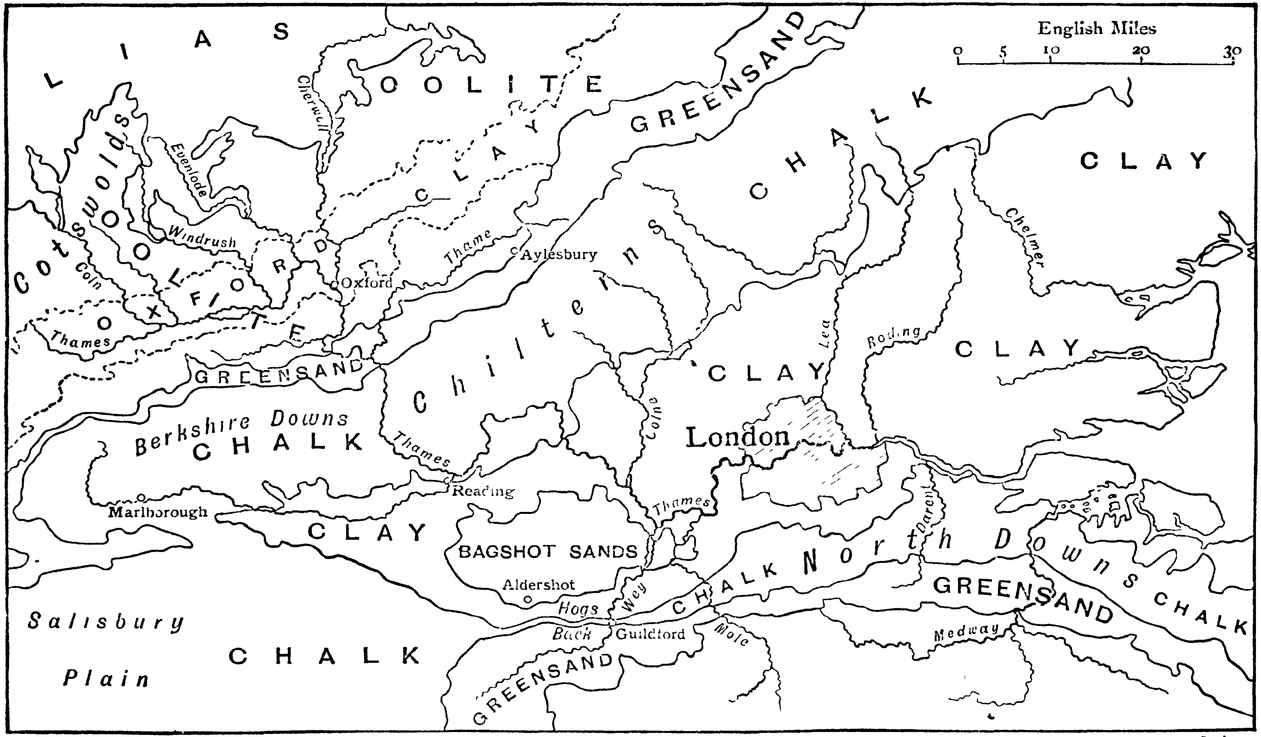

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FIG 104.—MAP OF THAMES BASIN, SHOWING FORMATIONS.

EXERCISES.

1. What is a sedimentary rock? Give examples.

2. From the contour map, describe the course of the Thames. What formations are crossed by the Thames?

3. Compare the east and west sides of England and Wales in as many ways as you can.

4. Name the chief tributaries of the Thames, and say where each takes its rise.

34. THE OOLITE RIDGE AND CLAY VALE.

THE *Oolite ridge* extends across England from the north of Yorkshire to the coast of Dorsetshire. It reaches its greatest height in the North Yorkshire moors, 1400 feet; the Cotswolds reach 1000 feet.

Oolite[1] (eggstone) is a kind of limestone; it is quarried near Bath and at Portland to provide building stone, the best layers being used for houses and public buildings, the inferior layers for walls between fields. Cement is also prepared from oolite. Iron ore is obtained from this formation in Wiltshire, Lincolnshire, and Yorkshire. The iron mines in the Cleveland Hills gave rise to the great smelting industry at Middlesbrough.

The headwaters of the Thames (the Isis, Colne, and Windrush) have their sources in the oolite; the Cherwell and Evenlode, however, rise west of the oolite and flow right across it. These rivers flow down the dip slope of the oolite, the scarp slope facing west.

The Cotswolds are covered with grass on which large numbers of sheep are pastured. The wool from these sheep provided the raw material of the woollen manufacture in the towns close by, such as Trowbridge and Chippenham in Wiltshire, Frome in Somersetshire, and Stroud in Gloucestershire. "West of England" goods are made at these places. The lack of mineral fuel in the district has hampered the development of the industry. Fuller's earth, used for removing grease from raw wool, is also obtained near Bath.

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[1] Under the microscope, oolite has some resemblance to the roe of a fish.

South of the Cotswolds the oolite formation crosses Wiltshire and Dorsetshire, terminating in the Isle of Portland (now joined to the mainland by a low-lying ridge of shingle).

North of the Cotswolds and Edge Hill the oolite crosses the midlands at a low elevation, passes through Northamptonshire and Lincolnshire, and then reappears in the North Yorkshire moors and Cleveland Hills; the cliffs on the coast near Whitby belong to this formation.

In Northamptonshire, where the oolite is lowest, grazing land for cattle covers large areas; dairy produce is sent to the large centres of population. Tanning leather and the manufacture of boots and shoes are important industries at Northampton

Oxford Clay Vale.—Between the Cotswolds on the west and the Chilterns and Berkshire Downs on the east there stretches a low-lying belt of clay; the belt begins in the Vale of Blackmoor in Dorsetshire, and thence it may be traced to the Fen country. South of Oxford, at the foot of the Berkshire Downs, it is called the Vale of the White Horse (so named from the figure of a horse cut on the chalk slope above the plain). North of the Thames it forms the Vale of Aylesbury and the upper valley of the Great Ouse. Throughout its extent the soil of the clay vale is fertile, and years ago it was largely used for growing wheat; now dairy-farming is more important, cattle being kept on the rich pasture land. Large quantities of milk are sent by rail to London.

Oxford, at the junction of the Cherwell and Thames, is noted for its university. It is an agricultural centre and market town.

Swindon is an important railway junction; the rolling-stock of the G.W.R. is made here.

Aylesbury is noted for agricultural produce and for making straw plait.

The Fens.—To the north-east the clay vale gets wider and lower, until it disappears beneath the deposits of mud brought by the rivers Welland, Nen, and Great Ouse. This area, called the Fens, was once covered with water, out of which rose a few islands. Ely is situated on one of them. The Fens have been drained, the water is pumped by windmills into canals and ditches, one part of the drained land being called the Bedford Level. The areas reclaimed in this way form excellent arable land.

On the edge of the Fens are many towns, *e.g.* Boston, in Lincolnshire, is a small seaport; Peterborough, on the Nen, is noted for agricultural implements and for brick-making; Cambridge, on the Cam, for its university; Bedford, on the Great Ouse, is a manufacturing town.

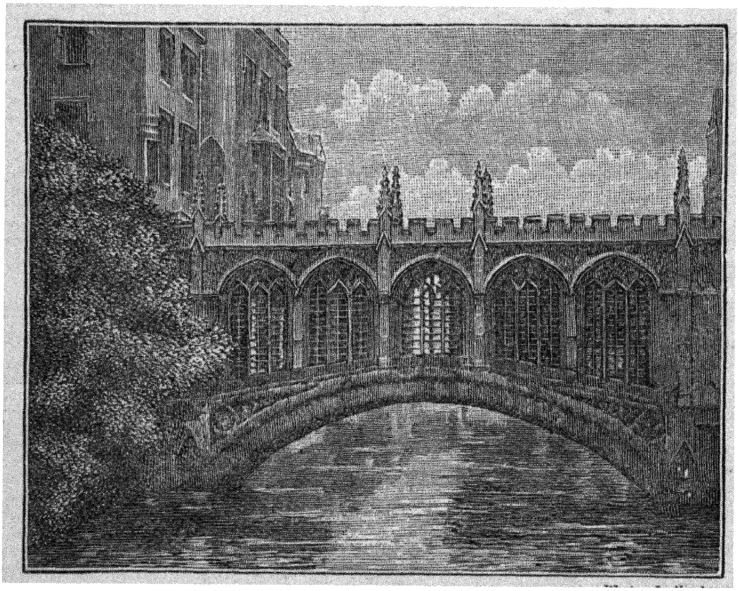

Photo J. Noaks.

FIG. 105.—BRIDGE OF SIGHS, ST. JOHN'S COLLEGE, CAMBRIDGE.

EXERCISES.

1. Say what you know of the productions of the oolite ridge.
2. Where are the following vales situated: Blackmoor, White Horse, Aylesbury? Of what formation are they?
3. Describe the Fen country. What rivers cross the Fen lands?
4. Say what you know of West of England goods: where are they made?
5. Write notes on the following: Portland, Cleveland, Northampton, Bath.

35. THE CHALK COUNTRY.

WITHIN the Thames basin the chalk formation includes the Chiltern Hills, the Berkshire Downs, Marlborough Downs, and North Downs. The dip slope of these hills is in each case on the side towards London.

Chalk hills are rounded in form and appear as rolling downs. They are usually covered with short grass on which sheep can be pastured. In chalk quarries and cuttings, layers of flint can often be seen. Ages ago, before men knew anything about iron, they used flints as spear-heads and as tools. Flint is now used for building churches, houses, and walls, for making roads, and in the manufacture of certain kinds of glass. Chalk is used largely in the preparation of lime (*e.g.* at Grays in Essex), and the chalky mud in the Medway estuary has given rise to cement making at Rochester.

Many rivers have cut transverse valleys through the chalk formation, *e.g.* the Thames, at Goring (near Reading); the Wey, at Guildford; the Mole, between Dorking and Leatherhead. In the Chiltern Hills are many gaps through the range (*e.g.* at Wendover), but there are no rivers in them. These riverless passages are sometimes called *wind gaps.*

As chalk is porous, rain sinks into it and reappears as springs near the junction of the chalk and clay formations. In consequence of this, there are many dry valleys in the chalk country. The Caterham valley in the North Downs (near Croydon) is an example of a dry valley; occasionally, however, water does flow when the chalk becomes thoroughly saturated. Over large tracts of the chalk country, then, no rivers will be seen (Fig. 104); the dry surface is more suitable for grass than for trees. Few trees are met with, but clumps of beech trees here and there present a striking contrast to the grassy slopes, *e.g.* the Knockholt beeches, on the edge of the North Downs in Kent.

Between Guildford and Farnham the North Downs form a narrow ridge of chalk, eight miles long, known as the Hog's Back. From this ridge on a clear day an extensive view can be obtained northwards across the Thames Valley and southwards across the Weald.

If the position of the chalk hills be examined with regard to London (Fig. 104), it will be seen that, except on the east, London is encircled by them. The main lines of railway from London must therefore pass through the chalk country, either through gaps, cuttings, or tunnels. The only one which does not do this is the G.E.R. main line to Yarmouth as it passes across the clay formation.

Beyond the Thames basin the chalk country extends in a north-easterly direction as the East Anglian Heights into Norfolk, where chalk cliffs appear near Hunstanton; thence it continues as the Lincolnshire Wolds and Yorkshire Wolds to Flamborough Head, a bold promontory of chalk which runs for several miles into the North Sea. Flamborough Head presents a striking contrast to the low-lying Spurn Head (at the mouth of the Humber) which consists of sand and shingle.

In the south of England the North Downs runs through Kent and terminates in the South Foreland near Dover (the white cliffs), and an offshoot appears as the North Foreland in the Isle of Thanet. Margate and Ramsgate on Thanet are now seaside resorts, but they originated as small fishing villages in gaps (or gates) of the chalk.

Dover is situated on a small harbour between the South Foreland and the Shakespeare Cliff. Its nearness to France and its strategic advantages have always made Dover important. **Folkestone**, situated at the foot of chalk hills, has steamship communication with Boulogne.

The South Downs run through Hampshire and Sussex to Beachy Head, a bold headland projecting out into the channel. Rivers have cut gaps through the South Downs; in olden times castles were built to guard these gaps, *e.g.* Arundel Castle on the Arun, Winchester on the Itchen, Bramber on the Adur, and Lewes on the Ouse. Roads and railways pass through these gaps as they afford the easiest routes.

On the coast of Sussex, **Brighton**, only 60 miles from London, lies at the foot of the chalk cliffs. **Newhaven**, at the mouth of the Ouse, is a packet station for Dieppe. **Eastbourne**, a watering-place, is on the east side of Beachy Head.

From Berkshire the chalk formation extends southwards across Wiltshire (Salisbury Plain) to Dorsetshire, where it appears on the coast at Lulworth and Swanage. The cliffs near Swanage were probably once connected with the Needles and the ridge of chalk which runs eastward through the Isle of Wight to Culver Cliff.

EXERCISES.

1. Explain the meaning of: Wind gap, dry valley, transverse valley.
2. Describe the uses of the chalk formation to the people who live near it.
3. Draw a sketch map to show where the main line railways from London pass through the chalk.
4. Name four chalk capes, and state the position of each.
5. Give three examples of gap towns, and describe the importance of each.

36. THE LONDON BASIN.

LONDON CLAY.—Between the Chilterns and the North Downs the chalk dips down in the form of a basin. The chief formation lying on the chalk is London clay, which is in some places several hundreds of feet thick; this clay is bluish in colour, but after exposure to the air it becomes brown. Other formations besides clay are beds of sand and pebbles, which in some places come up to the surface as (*a*) Bagshot sands, which are unsuitable for cultivation but provide excellent grounds for military manœuvres at Aldershot, (*b*) pebble beds at Blackheath, Keston, and Chislehurst, which are used as recreation grounds and common lands.

Rivers flowing across the London clay cut valleys in it and deposit gravel in their beds, thus leaving the hill-tops covered with clay, *e.g.* Forest Hill in south-east London. In the clay and other soft formations of the London district, tunnels for underground and tube railways and for road traffic have been made. Some of these pass under the Thames, *e.g.* the Blackwall and Rotherhithe tunnels, the Waterloo and City electric railway, etc.

The London clay is also useful for brick-making.

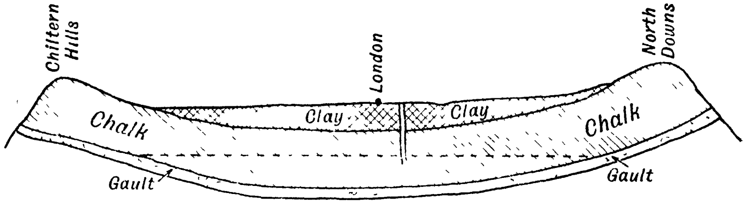

FIG. 106.—DIAGRAM SHOWING SECTION ACROSS THE LONDON BASIN.

London Water Supply.—London clay is an impermeable rock, that is, water cannot pass through it. Years ago, wells of no great depth were sunk through the beds of sand and gravel lying on the London clay; the water obtained from these wells was used for drinking purposes, but as London grew in size this surface water became more and more liable to pollution, and it is therefore never used at the present time. London is now supplied from three sources:

(1) River water, taken either from the Thames and stored up in reservoirs at Staines, or from the River Lea above Feilde's Weir.

(2) Water from natural springs in Hertfordshire, and brought to London by an artificial waterway (or aqueduct) called the New River.

(3) Water from artesian wells sunk through the clay into the chalk below. As chalk is a permeable rock, the rain which falls on the Chiltern Hills and North Downs sinks into the chalk but cannot pass through the gault, a stiff kind of clay, which lies beneath. The lowest part of the chalk becomes saturated, and if a well be sunk into this saturated chalk, water can be pumped out of it. The saturation level in the chalk (shown by a dotted line in Fig. 106) varies according to the rainfall on the Chilterns and North Downs and to the amount of water pumped out of the wells. The S.E. district of London is supplied with water from these artesian wells.

TOWNS.—Between London and Reading, the towns along the Thames are mostly residential because of their nearness to London and the attraction of the river. **Windsor** is noted for its castle, a royal residence; **Eton**, on the north side of the river, for its public school; **Maidenhead** for its beautiful position on the river, and Henley for its regatta. **Reading**, at the junction of the Kennet and Thames, has a good position for river traffic, as both rivers are navigable for small craft; it is also a meeting

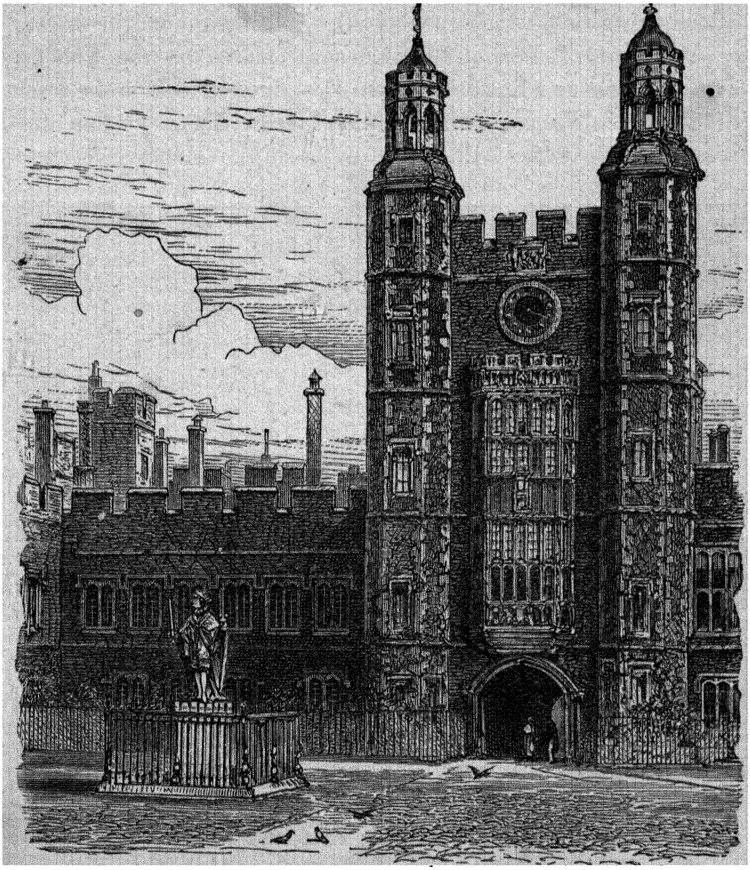

FIG. 107.—THE QUADRANGLE, ETON COLLEGE.

place for railways. The chief industry, biscuit-making, depends, in the first place, on the wheat lands of the district. Near Reading there are nurseries famous for seeds.

On the estuary of the Thames the towns have the advantage of the rising tide, which enables ships to come far up the river.

The Port of London[1] includes all places on the Thames estuary as far as a line drawn from Havengore Creek on the coast of Essex to Warden Point on the Isle of Sheppey (this line passes a little east of the Nore Light-ship). Hence Sheerness and Queenborough on the Isle of Sheppey, Rochester and Chatham on the Medway, form part of the Port of London.

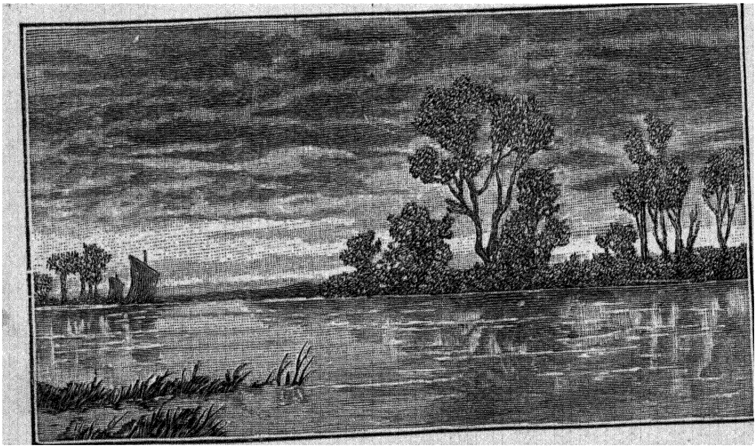

FIG. 108.—THE BROADS.

THE EASTERN COUNTIES.—The clay formation extends through the counties of Essex, Suffolk, and Norfolk. The sea has broken into the coast of Essex, forming deep inlets (*e.g.* Blackwater, Hanford Water), and it is rapidly undermining the cliffs of Norfolk and Suffolk. The shallow and reedy Norfolk broads are noted for fishing and yachting.

The undulating clay lands of the Eastern Counties were once covered with forests; Epping Forest, in Essex, is a small part of the original forest which remains. Nearly all the forests have been cleared in order to provide arable land; the clay soil, mixed with vegetable mould (decayed leaves and branches of trees), forms excellent soil for growing wheat, barley, oats, potatoes, turnips, and other crops. Many farmers keep cattle in order to supply London with milk and butter. The towns on the clay lands are therefore agricultural centres where farmers can sell their produce. Chelmsford, Colchester, Ipswich, and Norwich are towns of this type. Agricultural machinery and implements for farms and gardens can be obtained at these towns.

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[1] For a fuller description of London, see *Geography for Junior Classes*, pp. 100-103.

Coast Towns.—**Harwich**, on the Stour estuary, is an outport of London; packet steamers cross the North Sea to Antwerp and Rotterdam.

From **Yarmouth** and **Lowestoft** fishing-boats go to the Dogger Bank to catch herring, cod, haddock, and other fish.

Clacton, Walton, Felixstowe, are watering-places noted for sunshine and bracing air.

EXERCISES.

1. Say what you know of the formations in the London basin.

2 How does London get its water supply? Say what you know of the water supply in relation to the formations in the district.

3. What is an impermeable rock? Give examples.

4. Write notes on the following: Bagshot sands, Blackheath, Norfolk broads.

5. State the position and importance of: Reading, Rochester, Harwich

6. Name the chief places on the Thames estuary, and write a note about each.

37. THE WEALD AND HAMPSHIRE BASIN.

THE WEALD.—Between the North and South Downs the Weald stretches through Kent, Sussex, and Surrey. The word Weald means "forest," and centuries ago the whole of the district was covered with trees. Patches of woodland are still to be seen, but most of the forest land has been cleared.

The formation of the Weald was due to the denudation of the chalk. In the diagram, the dome of chalk which once covered the Weald is shown by dotted lines from the North Downs to the South Downs; this chalk has been carried by rivers to the sea; the Wey, Mole, Darent, and Medway carried some of these materials to the Thames; the Arun, Adur, and Ouse to the English Channel. Thus the clay and sand of the Weald became exposed, and the scarp slopes of the North and South Downs were left facing the Weald. It will therefore be noticed that the Wealden clay is an older formation than chalk, for it was originally *beneath* the chalk; London clay, however, was formed after the chalk, for it lies above the chalk.

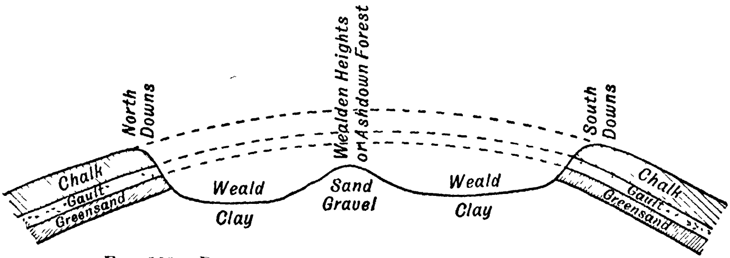


FIG. 109.—DIAGRAM SHOWING SECTION ACROSS THE WEALD.

The Weald is intersected by a ridge of sand and gravel known as the Wealden Heights or Ashdown Forest Range. In Leith Hill, in Surrey, this range reaches a height of nearly 1000 feet. Tunbridge Wells and Crowhurst are situated on the range. Near Hastings the range reaches the sea where it forms cliffs of considerable height. The Ashdown Forest Range is the chief watershed of the district; rivers rise in it, cross the Wealden plain, and then flow through gaps in the chalk in order to reach the Thames or English Channel.

In former times iron ore was mined in the Weald and wood charcoal was used to smelt it. The Weald is now noted for agriculture, hops being grown in large quantities on the Wealden clay. Cereals and fruit are also grown.

Tonbridge, on the Medway, is a market town; two important railways meet here, viz. the main line of the South-Eastern and

Chatham from London to Hastings, and the railway from Dover to Aldershot and Reading.

Ashford, on the Stour, is a centre for hop cultivation; it also has a sheep and cattle market and railway works.

Romney Marsh. This has now been reclaimed from the sea; it consists of wide stretches of flat land covered with grass and rushes, and intersected with many ditches to carry off the water. Sheep and cattle are grazed on the marsh-lands. **Rye**, a quaint old town at the mouth of the Rother, stands on a hill, which once formed an island surrounded by the sea.

Hampshire Basin. In the southern part of Hampshire the formations are almost exactly like those in the London clay district of the Thames basin. The land round Bournemouth (and Poole harbour in Dorsetshire), the New Forest, the eastern side of Southampton Water, and the northern part of the Isle of Wight, consist of Bagshot sands with a rim of clay all round. Beneath these formations are strata of chalk and greensand just as in the London basin. The sandy surface of this area makes the soil too poor for agriculture, hence the New Forest has always been a woodland district; heather and pine woods cover large areas near Bournemouth.

Southampton stands at the head of the Southampton Water at the mouth of the River Itchen. It has the advantage of two tides every twelve hours. Southampton has great trade with France, South Africa, West Indies, South America, and New York.

Portsmouth, at the entrance of Portsmouth Harbour from Spithead, is a great naval station.

Cowes, in the Isle of Wight, is noted for yachting, which takes place in the Solent and at Spithead.

EXERCISES.

1. Explain how the Weald was formed.
2. Write a short account of the Ashdown Forest Range.
3. What formations would you cross in walking from the North Downs to the South Downs? Write notes on these formations.
4. State the position and importance of: Ashford, Rye, Bournemouth, Portsmouth.
5. Write a short account of—(*a*) the New Forest, (*b*) Romney Marsh.

38. THE TRENT BASIN.

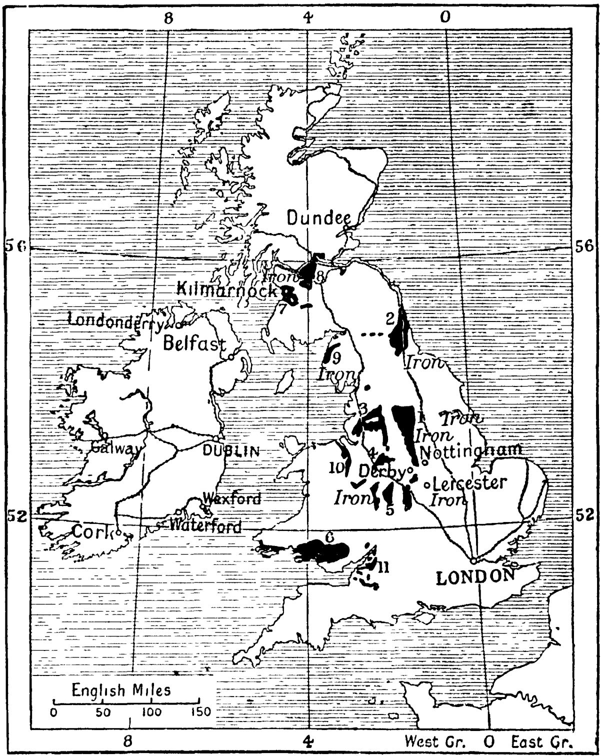
THE River Trent rises on the south-western side of the Peak District. After flowing a short distance to the south across the North Staffordshire coalfield, the Trent makes a bend first east and then north in order to reach the Humber. Two of its tributaries, the Dove and Derwent, also rise in the Peak District; on the right bank the chief tributaries are the Tame and Soar.

The Red Plain.—If lines be drawn on a map to connect the towns **Birmingham, Leicester, Nottingham,** and **Stafford,** the area within the four-sided figure forms the most important part of the Red Plain. The formations which give a reddish appearance to the soil and to cuttings in the plain are (*a*) new red sandstone and (*b*) red marl, a kind of clay. These red rocks extend in three directions beyond the area marked out in this way: (1) to the south-west along the lower Severn valley, (2) to the north-west to the coast of Cheshire, and (3) through Nottingham and Yorkshire east of the Pennines.

Coal-bearing strata, however, protrude through the red rocks, and so coalfields form an important feature of the plain.

The Red Plain was in former times covered with forests, *e.g.* Charnwood Forest near Leicester. The towns Nottingham, Derby, Leicester, and Stafford are old strategic towns dating back to the time of the struggle between Danes and Mercians. The plain is now used for agriculture and pasturage; cattle-grazing is particularly important on the rich grass lands bordering the Trent. Dairy produce is sent to London, Birmingham, and other great cities. Sheep, of which the Leicester breed is noted, are kept on the drier uplands. Hence the towns on the plain have always been market towns, but owing to the presence of coalfields some of them have developed into industrial towns as well. Boots and shoes are manufactured at Leicester and Stafford; hosiery is made at Leicester and Nottingham; lace-making at Nottingham. **Burton-on-Trent** specialises in brewing beer, as the water contains gypsum dissolved from the red marl. **Derby**, on the Derwent, the headquarters of the Midland Railway, makes railway rolling-stock.

The Coalfields.—(*a*) The Leicestershire and Warwickshire coalfields are situated between the rivers Tame and Soar. No important industries have become localised on these coalfields. **Coventry**, a few miles south of the Warwickshire coalfield, manufactures cycles and motors.



Stanford's Geog' Estabt. London.

FIG. 110.—COAL- AND IRON-FIELDS OF GREAT BRITAIN.

(*b*) The South Staffordshire Coalfield.—The Black Country has become one of the most prosperous of the industrial areas of England, because coal and iron ore were both found in the district. In the neighbourhood of Birmingham iron ore was first smelted with wood charcoal, and then coal was used as fuel in the furnaces. Two other articles required for smelting were also found in the district, viz. limestone to act as a flux, and Stourbridge fire-clay from which bricks were made to line the furnaces.

The metal thus obtained is made into all kinds of hardware. **Birmingham** is the centre of the hardware trade, and it now exceeds all the neighbouring towns in size and in wealth, and is therefore often called the capital of the Midlands. **Wolverhampton, Walsall, West Bromwich, Dudley,** and other towns near Birmingham are all engaged in ironwork.

(*c*) North Staffordshire Coalfield.—This district is known as the Potteries. The earthenware was in the first place made from the clays of the district; now only the commoner kinds are made from the local clays. Porcelain is made from kaolin or china clay imported from Cornwall and Devon. The chief centres of industry are **Stoke-on-Trent,** Hanley, Burslem, Newcastle-under-Lyme.

The Cheshire Salt District.—To the north-west of the Potteries is the salt district of Cheshire. Rock salt is mined extensively at **Northwich, Middlewich, Nantwich,** all situated in the Weaver valley. Large quantities of salt from this district are used in the chemical works of Widnes and Runcorn on the Mersey.

EXERCISES.

1. State the position of the Great Red Plain. Of what rocks is it composed?
2. Name the most important towns on the River Trent, and describe the importance of each.
3. Write an account of the county of Staffordshire, with special reference to the industrial and agricultural areas.
4. Write notes on the position and importance of: Derby, Leicester, Stoke, Nantwich.
5. Name a port on the Mersey, Severn, Humber, and Thames respectively through which Birmingham goods might be exported. Find in miles the distance of each port from Birmingham.

39. THE SEVERN BASIN.

THE River Severn rises in Plynlimmon, one of the highest mountains in Central Wales. It flows in a narrow valley through the mountainous county of Montgomery, passing through the towns Newtown and Welshpool where flannel is made. The chief tributary in this part of its course is the Vyrnwy; across the upper part of the valley of this river a dam has been built in order to form a lake; this lake provides Liverpool with a part of its water supply.

The Severn then enters the fertile plain of North Shropshire, across which it flows in a very winding course; in one of the bends of the river stands **Shrewsbury**, which was in olden times a strong fortress guarding the Welsh march-land; now it is a prosperous market town and a great railway junction. A few miles below Shrewsbury the river flows between an isolated mountain called the Wrekin on the left and a spur of Wenlock Edge on the right, and turning south enters a narrow gorge near Coalbrookdale and Ironbridge (the names of these places have reference to the mining district in the neighbourhood). At the southern end of the gorge is Bridgnorth, once an important position of defence, now a market town and carpet-making centre.

Still flowing south, the Severn crosses the wide plain of Worcestershire, a county noted for agriculture and fruit-growing On the left bank it first receives the Stour, a small but important stream because of **Stourbridge** noted for its fireclay and **Kidderminster** for its carpet industry. **Worcester**, an old cathedral city, stands near the junction of the Teme; it manufactures porcelain (Royal Worcester) and gloves. West of the Severn, the Malvern Hills, composed of ancient rocks, stand up boldly above the red rocks of the plain. At **Tewkesbury** the Avon joins the Severn; the Avon flows in a broad fertile valley parallel to the oolite escarpment of the Cotswolds and Edge Hill. Fruit is extensively grown in the valley, and many agricultural towns (*e.g.* Warwick, Stratford, and Evesham) are situated on the river.

Gloucester stands at the head of the Severn estuary. Originally a Roman station for defence, it became in later times an important bridge town. Until the Severn tunnel was opened, traffic from London to South Wales went by way of Gloucester. Below Gloucester the river has many sharp bends which render the navigation difficult. The tide flowing into the funnel-shaped estuary from the broad Bristol Channel forms a wave called a *bore*; at spring tides this causes a rise and fall of nearly 40 feet. The bore makes another difficulty in the navigation of the estuary. To overcome these disadvantages to some extent a ship canal (the Berkley Canal) has been made from Sharpness to Gloucester, but it is only suitable for small craft. Grain and timber are carried along this canal to Gloucester.

The Wye, like the Severn, rises in Plynlimmon; for a considerable distance the Wye forms the boundary between the counties of Radnor and Brecknock. These counties consist almost entirely of mountains and bare moorland. The whole region is unproductive, and consequently the population per square mile is very small.

As the Wye crosses the plain of Hereford it passes through a very fertile district in which hops and fruit are grown in large quantities; **Hereford**, like Devonshire, is noted for cider. The city of Hereford is an agricultural centre.

Between Hereford and Chepstow the Wye cuts a gorge through the limestone and forms a series of loops which make this part of the valley very picturesque. From a height, called Symon's Yat, the Wye can be seen bending round in the shape of the letter S; the ruins of Tintern Abbey are beautifully situated in the valley a few miles north of Chepstow. Between the Wye and Severn is the Forest of Dean coalfield.

The Bristol Avon rises on the east side of the Cotswolds. After passing Bath and Bristol the river cuts through the limestone ridge, forming a narrow gorge at Clifton, and then crossing the alluvial lowlands to reach the Bristol Channel.

Bath is surrounded by hills; it is noted for its mineral springs, which have been used medicinally and for baths ever since the time of the Romans.

Bristol is a very old seaport; in early days its trade was almost entirely with Ireland; later its trade with West Africa and America developed. Cocoa, tobacco, sugar, tropical fruits are imported in large quantities. The navigation of the Avon through the gorge is very difficult for large ships, hence docks have been constructed at **Avonmouth.**

The Bristol coalfield lies east of the city; no industry has become established in the mining district, the coal being chiefly used in the factories of Bristol.

EXERCISES.

1. Describe the agricultural districts through which the Severn passes.
2. Write notes on the following: Wrekin, Malvern Hills, Symon's Yat.
3. Why has Gloucester never become a great seaport?
4. Compare the Bristol Avon with the Stratford Avon.
5. Name the coalfields in the Severn Basin, and point out the importance of each.
6. Say what you know of the following towns: Shrewsbury, Bridgnorth, Bath, Hereford, Worcester.
7. Write an account of the port of Bristol.

40. THE PENNINES.

THE Pennines consist chiefly of two formations—carboniferous (carbon-bearing) limestone and millstone grit. They are both sedimentary rocks, that is, they were formed in layers or strata at the bottom of the sea. The coal measures were afterwards formed above the limestone. At a later period the limestone was pushed up through the overlying strata, and after denudation had taken place the rocks remained as we find them now, viz. an uplift of limestone with coalfields on each side.

The northern and southern parts of the Pennines are composed mainly of limestone, the central part between the Lancashire and Yorkshire coalfields being millstone grit. These two formations account for the striking contrast in scenery in different parts of the Pennines. The limestone often appears in horizontal layers; in many river valleys the layers become a series of steps or terraces, thus forming waterfalls (*e.g.* the Aysgarth Falls in the Ure valley). In other places the limestone has been tilted, thus presenting a scarp and a dip slope.

Limestone is readily dissolved by water, especially if the water contains carbonic acid, and so many streams disappear into holes and flow in underground channels for considerable distances; the River Aire does this for more than a mile.

Caverns have also been formed by the dissolution of the limestone. In many of these caves the water dripping from the roof has formed *stalactites* hanging from the roof and *stalagmites* on the floor of the cave. **Castleton** in the Peak District and **Ingleton** near Ingleborough are noted for these caves.

Millstone grit is harder than carboniferous limestone and not so easily acted on by water; the surface, however, weathers into holes and it becomes rough moorland; the smoother, grass-covered limestone has a very different appearance from the rough, broken grit. As water does not pass readily into the millstone grit, reservoirs can be made to collect water for the towns in the industrial area close by; the water thus obtained is soft and particularly suitable for use in dyeing cloth.

The chief heights in the Pennines are Cross Fell, Whernside, Ingleborough, and the Peak. The range forms an important watershed for rivers flowing to the North Sea and Irish Sea. The water parting is nearer the west than the east coast, hence the longer rivers flow to the North Sea. The rivers Swale, Ure, Wharfe, Aire, Nidd have scored out the limestone into a series of deep valleys called "*dales*"; the Don does not form a dale as it flows across the hard millstone grit.

At two places the Pennines can be crossed at an elevation less than 500 feet: (*a*) the Tyne gap, which provides a route from Newcastle to Carlisle (N.E.R.); (*b*) the Aire gap, which provides a route from Leeds to Carlisle (Mid. R.). Communication between the woollen towns of the West Riding and the cotton towns of South Lancashire is carried on by railways which pass up the valleys on the sides of the Pennines and then through tunnels; *e.g.* the L.N.W. Railway from Leeds to Manchester follows the Calder valley, passes Huddersfield, and then goes through the Standedge Tunnel (3 miles long).

THE COALFIELDS.

(*a*) *South Lancashire.*—Through the coal measures, masses of millstone grit, known as the South Lancashire Moors, stand up like islands; they are partially covered with grass and bog. **Wigan**, the centre of the coal-mining industry, is situated near the south-western edge of the moors.

Cotton-spinning became established in South Lancashire because of the wet climate. The cotton towns are situated on the plain and in the valleys which intersect the moorlands. **Bolton** and **Bury**, on the Irwell, are at the southern edge of the moors; **Blackburn**, **Accrington**, and **Burnley** on the northern edge. Near Manchester, on the Irwell, are **Oldham**, **Ashton**, and **Stockport**.

Manchester is a city of warehouses; cotton goods are stored ready for export. In the docks at Salford ships are laden with cotton goods to the value of ten million pounds a year. From Salford to Eastham, where the ship canal enters the Mersey, is a distance of 36 miles.

Liverpool, with the exception of London, is the greatest seaport in the British Isles. It is not on the coalfield, but it exports the articles manufactured in the industrial towns of South Lancashire. The value of the cotton goods shipped at Liverpool is at least six times the value of that shipped at Manchester. Liverpool also exports articles manufactured on other coalfields besides South Lancashire, *e.g.* West Riding of Yorkshire, the Potteries, Black Country, North Wales.

(*b*) *York, Derby, and Nottingham Coalfield.*—This coalfield extends from the Aire valley southwards to the Trent. In Derby and Nottingham large quantities of coal are raised, but no important industries have become localised; hence there are no very large towns. **Chesterfield** is the centre of the coal trade. In the West Riding iron ore is mined, and smelting takes place at **Rotherham**. Iron and steel goods, especially cutlery, are made at **Sheffield** on the Don; millstone grit from the Pennines being used for grindstones. The Yorkshire woollen industry was first established by Flemings who settled in the valleys of the West Riding. Raw wool was obtained from sheep on the Pennines and the streams provided water for cleansing the wool. The development of coal-mining and the use of steam-power brought about a great extension of the industry.

Leeds on the Aire, as well as Bradford, Huddersfield, Halifax, Wakefield, and Dewsbury are all engaged in making woollen fabrics.

The Humber ports appear to be the natural outlet for goods manufactured in the West Riding; large quantities are, however, sent to Liverpool, London, and Southampton for export.

Hull, on the north side of the Humber, exports coal, woollen goods, and iron goods from the West Riding. It has great trade with continental ports on the North Sea and Baltic Sea. **Goole**, at the head of the Humber estuary, is a growing port, and **Grimsby**, in Lincolnshire, is not only a great fishing port but it is becoming an important commercial port.

(*c*) *Northumberland and Durham Coalfield.*—This coalfield occupies the south-east part of Northumberland and nearly the whole of Durham; it is crossed by the rivers Blyth, Tyne, and Wear. The nearness of the coal to the coast has resulted in a great export trade, and in connection with this trade the ship-building industry grew up on the Tyne. Ships are now built on the Tyne from **Newcastle** to Shields; also at **Sunderland** on the Wear and at **Hartlepool** on the Tees.

Iron-smelting is the chief industry at Middlesbrough on the Tees because of its nearness to the Cleveland Hills; ironworks employ many people at Stockton and Darlington.

The **Vale of York** is a very important agricultural area; the soil is very fertile and large quantities of cereals are grown. Cattle and sheep are grazed on the pasture lands. **York**, on the Ouse, is a very old city; it is an agricultural centre and noted for its flour market. York is situated on the east coast route to Scotland, and is a meeting-place for many roads and railways. **Selby**, lower down the Ouse valley, is also a market town.

EXERCISES.

1. Write an account of the Pennine chain as regards formation.
2. Say what you know of means of communication across the Pennines.
3. Write notes on the following: Millstone grit, stalactites, dales.
4. Explain briefly why cotton goods are made in South Lancashire and woollen goods in the West Riding.
5. Draw a sketch map of the rivers which flow across the West Riding and mark the chief industrial towns.
6. State the position and trade of Liverpool, Hull, Newcastle.

41. THE MOUNTAINS OF THE WEST.

IN Lesson 33 the hardness of the rocks and the bold scenery of the west of England and Wales were referred to.

Many centuries ago the British Isles were covered with ice, just as Greenland is covered with a thick ice-cap at the present time. The pressure and movement of the glaciers on the sloping rocks partly account for the shape of the land surface now. The work done by glaciers is known as glaciation, and there are many evidences of it to be seen in Cumberland and Wales.

Evidences of Glaciation.—As the glaciers moved down the mountain valleys stones and rocks became embedded in the ice and they made scratches on the mountain sides; the rocks beneath the glacier were smoothed and polished as the ice moved over them. When the glaciers melted, the stones brought by them were left as moraine deposits, and these deposits often held up the water to form lakes. Great blocks carried by the glaciers were slowly lowered as the ice melted, until they were left as perched blocks or rocking-stones. These evidences of glaciation can be seen in the Pass of Llanberis in North Wales and in Borrowdale in Cumberland.

The Lake District.—This district is separated from the Pennines by a fault or break in the rocks between Cross Fell and Shap Fell. The mountains in the Lake District form a group of peaks; glaciated valleys radiate from a central mass. **Scafell**, the highest mountain, overlooks Wastwater from which the River Irt flows; **Helvellyn** towers up above Ullswater from which the River Emmott flows to the Eden; **Skiddaw** is situated near Derwentwater and Bassenthwaite, both drained by the River Derwent. The mountains round Windermere, the largest lake in the district, are not so high; the River Leven flows from Windermere to Morecambe Bay.

The Lake District is essentially a tourist country, **Keswick** and **Ambleside** being two convenient tourist centres. The railway from Penrith to Cockermouth *via* Keswick is the only one which goes through the district; the other parts are crossed by roads and tracks. On Windermere and Ullswater there are small steamers.

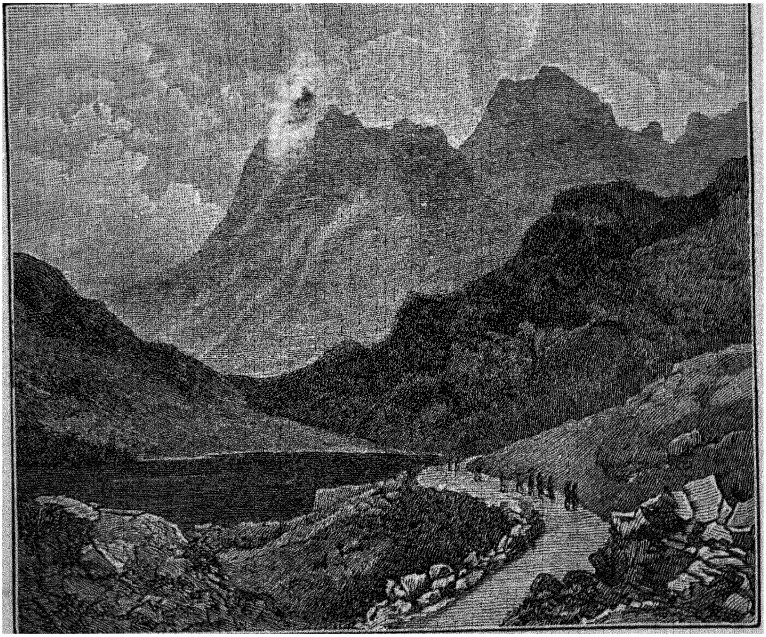


FIG. 111.—LANGDALE PIKES.

The rainfall in the Lake District is very heavy and mists often cover the mountains and obstruct the view. At **Seathwaite**, near Scafell, the heaviest rainfall (133 inches) in the British Isles has been recorded.

Sheep are turned out to graze on the mountain sides.

Lead and zinc are mined and slate is quarried.

Keswick still manufactures black-lead pencils, although the graphite mines in Borrowdale are no longer productive.

From Thirlmere, a lake on the west side of Helvellyn, the city of Manchester draws part of its water supply—the distance being about 90 miles.

The Cumberland Coalfield.—North-west of the Lake District, on the coast of Cumberland, is a coal-mining district; **Whitehaven**, Workington, Maryport export coal, and Workington also smelts iron ore brought from Spain.

Carlisle.—North of the Lake District is an extensive plain crossed by the River Eden. Agriculture and dairy-farming are the chief industries. Carlisle, the only large centre of population, is an important market town. In olden times Carlisle was a position of defence on the western road to Scotland. Now it is one of the busiest railway junctions in the British Isles. Surrounded by mountains on three sides, the valleys along which the railways run all focus on Carlisle. Seven important routes meet at Carlisle.

North Wales.—In the mountains and valleys of North Wales signs of glaciation are to be seen everywhere. The rivers Conway, Clwyd, and Dee flow through glaciated valleys; Lakes Bala, Llanberis, and Ogwen were formed by moraines in valleys which were once filled by glaciers. **Snowdon**, the highest mountain in Wales, and Moel Siabod are two of the prominent peaks in the district.

The most valuable production is slate obtained from the quarries at **Bethesda, Festiniog**, and **Llanberis.** From Penmaenmawr, a great mass of igneous rock, stone for road metal, is obtained. Lead is mined in several parts of the district.

Large numbers of sheep are grazed on the mountains, and they are valuable partly for food (Welsh mutton) and partly for the wool. Welsh flannel is made at **Welshpool, Newtown,** and many other places.

Coalfield.—The North Wales coalfield is in the counties of Flint and Denbigh, **Wrexham** and **Ruabon** being the chief towns. In connection with this coalfield, boiler-works and electrical works have been established at Queensferry on the Dee.

Communication.—Railways have been made along the chief river valleys; *e.g.* from Ruabon a railway runs along the Dee valley past Lake Bala to Dolgelly and Barmouth; from Llandudno Junction a railway runs along the Conway valley *viâ* Bettws-y-Coed to Festiniog.

The most important railway, however, follows the coast from Chester *via* Rhyl and Bangor to Menai Bridge and so on to Holyhead.

Carnarvon, an old strategic town, overlooks the southern end of Menai Strait.

Anglesey, separated from the mainland by Menai Strait, is a very flat low-lying island which supports great numbers of cattle. Beaumaris is the chief town.

EXERCISES.

1. What is meant by glaciation? How would you recognise a glaciated region?
2. Say what you know of the Lake District as regards—(*a*) climate, (*b*) productions, (*c*) communication
3. Describe the position of Keswick and Ambleside. What mountains and lakes are near these towns?
4. Draw a sketch map to show the railway routes which meet at Carlisle.
5. Write a short account of the physical features of North Wales.
6. Describe the railway route from Chester to Holyhead.

42. THE MOUNTAINS OF THE WEST (*continued*).

SOUTH WALES.—The highest mountains in South Wales, the Brecknockshire Beacons (2900 feet) and the Black Mountains, are composed of Old Red Sandstone. The River Usk has cut its valley between these mountain masses, and then turning south it enters the Bristol Channel at Newport. From the Brecknockshire Beacons many rivers (Taff, Neath, and Tawe) flow across the coast plain, the vale of Glamorgan, to the Bristol Channel.

They cross the South Wales coalfield, and along their valleys railways run from the mines to the ports. The coal measures reach the coast of Swansea Bay and Carmarthen Bay, but they are several miles away from Cardiff. The eastern part of the coalfield produces *bituminous* coal, the western part near Swansea produces *anthracite* or steam-coal. Anthracite or smokeless coal is most useful for war-ships and blast furnaces.

Iron ore was once mined in the hills round **Merthyr Tydvil** and iron-smelting became established. Iron ore is now imported from Spain to supply the furnaces at Merthyr, Tredegar, and Dowlais.

The smelting industry at **Swansea** began when tin and copper were mined in Cornwall and Devon. Tin ore, imported from the Malay States, and copper ore from Southern Spain, are now smelted at Swansea and Llanelly. The towns of South Wales, especially Merthyr, Swansea, and Cardiff, are noted for ironworks, tin-plate goods, and galvanised ware. The exportation of coal from **Cardiff**, Swansea, Newport, and Port Talbot is very great.

In Pembrokeshire is the fine harbour called Milford Haven. **Pembroke** is noted for its naval dockyard and Milford for fishing.

The South-western Peninsula.—There are two high regions—(1) Exmoor, a sandstone plateau in North Devon and Somerset, and (2) Dartmoor, a granite plateau in South Devon.

West of Dartmoor masses of granite appear but decreasing in height, namely, the Bodmin Moors, near St. Austell and Redruth, Land's End, and the Scilly Isles. The Scilly Isles are probably what remains of a granite area which once extended westwards from Cornwall.

Granite weathers into great oblong blocks; the highest of these masses are called Tors, as Yes Tor in Dartmoor. Decomposed granite is found in beds and is known as kaolin or china clay; this clay is exported to the Potteries from Fowey and Teignmouth to be used for making porcelain. Near the granite masses in Cornwall slate occurs, and some of it is quarried. Mining for tin and copper was once the most important industry; many of the mines are exhausted, and in others the ore can now only be obtained from very deep workings.

The moorlands of Devon and Cornwall are partly covered with grass, which provides pasturage for large numbers of cattle and sheep. Dairy-farming is one of the most important industries, butter and cream being particularly noted. In the valleys and on the lowlands agriculture is carried on; fruit and early vegetables are grown, cider being made from apples. From the Scilly Isles flowers are sent to the London markets.

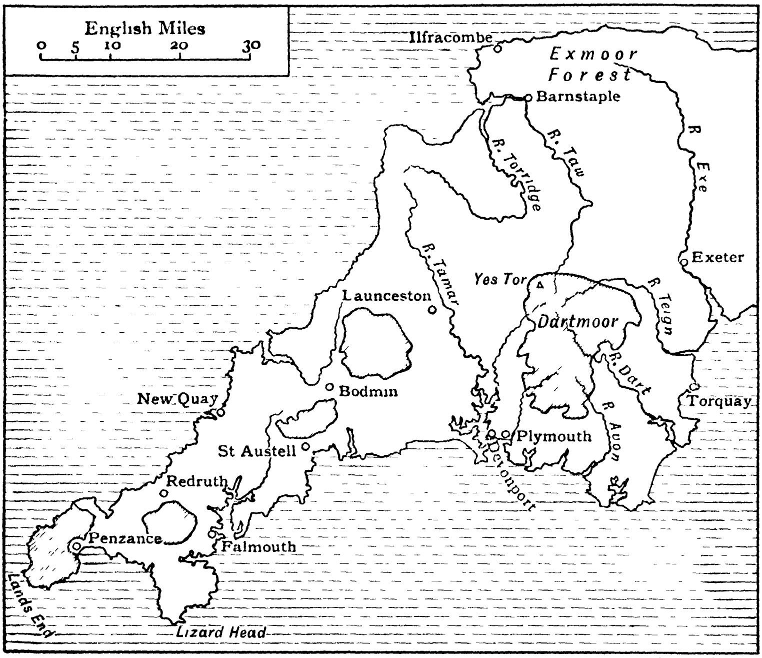


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FIG. 112.—THE SOUTH-WEST PENINSULA.

The shaded areas are of granite formation.

Many people are engaged in fishing, especially for pilchards and mackerel; fishing fleets go out from Brixham, Falmouth, St. Ives, and Penzance.

Plymouth, on Plymouth Sound, is a calling place for liners on their way up the Channel.

Devonport has a naval dockyard. **Exeter**, on the Exe, is a very old town, and is an important agricultural centre.

Torquay, Newquay, Bude, and many other places on the coast of Cornwall and Devon, are health resorts on account of the warm climate and high temperature in winter.

Taunton, in Somersetshire, is the centre of the fertile vale of Taunton; it is also a railway junction on the routes into Devon.

To the east the vale of Taunton opens out to the flats of Sedgemoor; this district, once marsh-land, has now been drained and is used for pasturage.

Bridgewater, at the mouth of the Parret, is a small town.

EXERCISES.

1. Write an account of the smelting industry in South Wales.

2 What kinds of coal are mined in South Wales? State the uses of each kind of coal

3. Draw a sketch map of the Bristol Channel, and mark on it the chief seaports.

4. Say what you know of the granite formation in Devon and Cornwall.

5. Describe the position and importance of: Cardiff, Plymouth, Taunton, and Pembroke.

6. Write notes on: the vale of Glamorgan, the vale of Taunton, Exmoor, Sedgemoor.

43. RAILWAYS AND CANALS.

ON looking at Fig. 113, the chief railways of the British Isles can be seen; if this map be compared with a contour map, the routes taken by the various railways can be studied in relation to the physical features. Certain nodal towns have become important railway junctions, and a few of these will be pointed out; many others, however, can be found from the map.

(*a*) **London.**—From London railways radiate in all directions; each railway company has a terminus of its own, *e.g.* Paddington, the terminus of the Great Western Railway. Passengers passing through London must change from one terminus to another, as there is no through service in connection with the various railways.

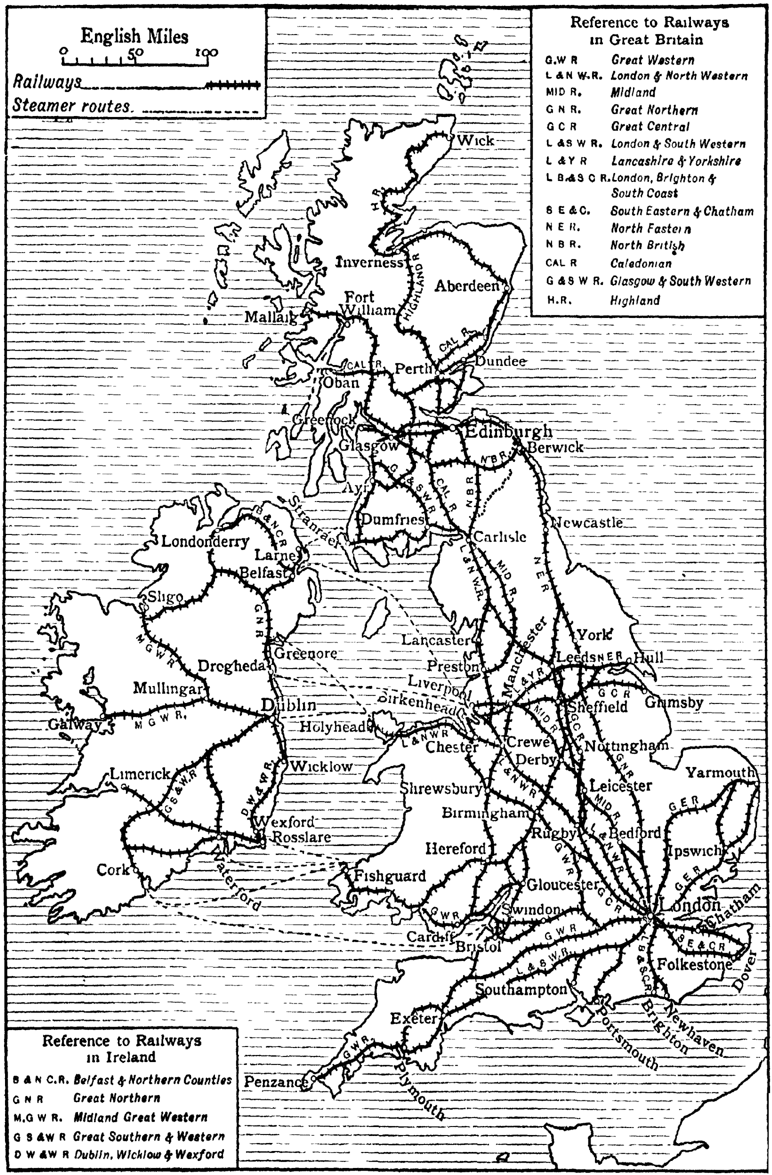

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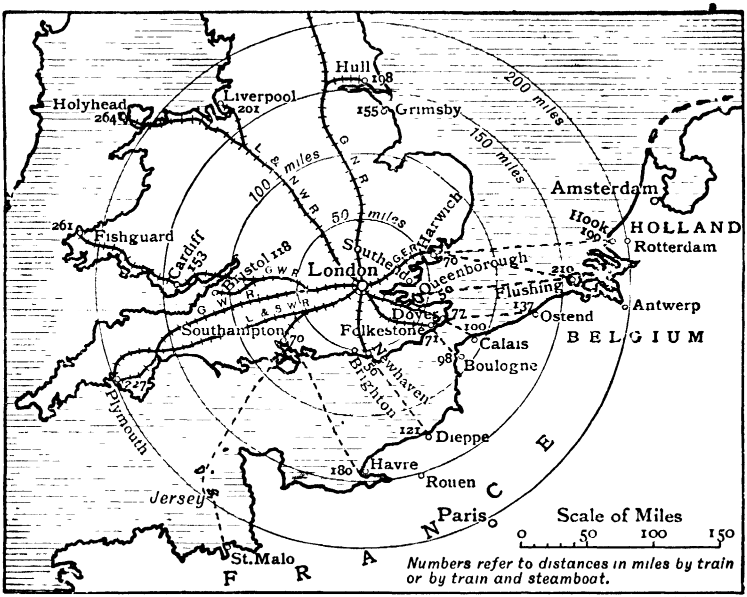
FIG. 113.—CHIEF RAILWAYS IN THE BRITISH ISLES.

(*b*) **Crewe** is essentially a railway town. It is the creation of the London and North-Western Railway Company, and nearly all the inhabitants are employed by the railway company in making locomotives and rolling-stock.

All the railway lines which meet at Crewe are owned (or partly owned) by the London and North-Western Railway.



Numbers refer to distances in miles by train or by train and steamboat.

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FIG. 114.—ROUTES FROM LONDON.

Crewe is in Cheshire, and occupies a very convenient position in the Midland Gate between the mountains of Wales on the west and the Peak District to the north-east. From Crewe, therefore, railways branch off to London, Manchester, Preston, Liverpool, Holyhead, and Shrewsbury.

(*c*) **Carlisle** is a very old strategic town on the western road into Scotland. Except on the west, it is surrounded by mountains, and all the routes through the mountains focus on Carlisle. The Glasgow and South-Western Railway from Glasgow comes down Nithsdale. The Caledonian Railway from Glasgow and Edinburgh comes down Annandale; the North British Railway from Edinburgh comes down Liddesdale; the North-Eastern Railway from Newcastle crosses the Tyne gap; the Midland Railway from Leeds follows the Eden Valley; the London and North-Western Railway from Crewe crosses Shap Fell and then follows the Petterill Valley; the Whitehaven and Maryport Railway crosses the plain of Cumberland.

On the east side of the Pennines there is no railway junction to compare with Carlisle as there are few mountains in the way. The main line to Scotland traverses the low-lying land of the north-eastern counties.

(*d*) **Shrewsbury** resembles Carlisle in some respects as it commands various routes through the mountains of Wales, and it can be easily approached from the central plain of England.

(*e*) **Manchester**, **Leeds**, and **Sheffield** are respectively the meeting-place of many railways, because each of them is on a coalfield and is an industrial centre with enormous trade.

(*f*) **Stirling** is on the River Forth. The central position of Stirling makes it an important railway junction as it commands the various routes to Glasgow, Edinburgh, Perth, and Oban.

(*g*) **Dublin.**—As a railway centre Dublin corresponds in some respects with London, as all the important railways of Ireland radiate from it, *e.g.* westward to Galway, northward to Belfast and Londonderry, southward to Wexford, and south-west to Cork and Queenstown.

Canals.—Before the advent of railways many canals were constructed in order to connect the navigable rivers and so provide a means of communication for heavy goods. With the development of railways, however, the canals became less important, and some of them were disused, especially where they were likely to compete with the railways. The congestion of traffic on the railways at the present time has again drawn attention to the canals as a useful means of transport.

Heavy, bulky articles can be carried on canals, and especially goods that can stand a long journey without spoiling. Coal, bricks, clay, manure, can with advantage be carried in barges.

On Fig. 115 it will be seen that many barge canals link up the rivers on the Midland Plain.

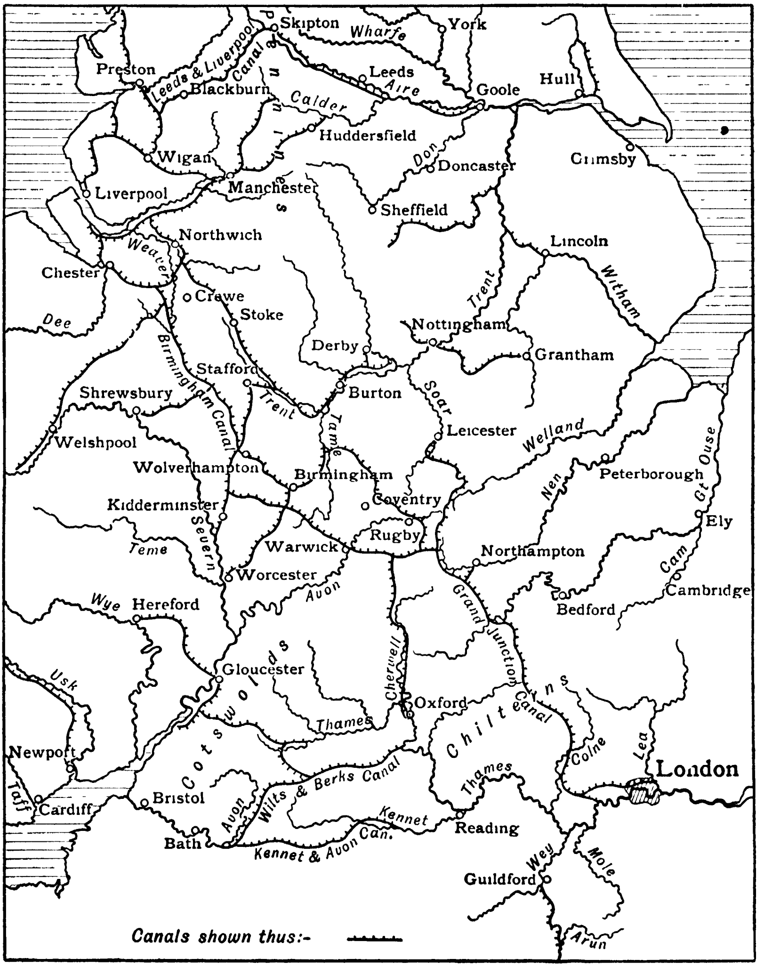

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FIG. 115.—MAP OF CENTRAL ENGLAND SHOWING CANALS.

(*a*) **The Grand Junction Canal** connects London and Birmingham by way of the Colne, a tributary of the Thames. **The Birmingham Canal** passes through Wolverhampton and

Chester to the Mersey estuary. It would therefore be possible to send goods by canal from London to Liverpool.

(*b*) The Tame, a tributary of the Trent, is joined to the Severn by a canal which passes through Birmingham, hence goods might be sent from Gloucester to the Humber ports.

(*c*) The Thames is connected with the Severn by the Kennet and Avon Canal and the Wilts and Berkshire Canal, both of which enter the Bristol Avon, and by a canal which crosses the Cotswolds and joins the Severn near Gloucester.

(*d*) **The Leeds and Liverpool Canal** connects the cotton towns of South Lancashire with the woollen towns of the West Riding. Starting from Liverpool it passes to Wigan, where a branch from Manchester joins it, and then on to Blackburn. The canal crosses the Pennines by a series of locks through the Aire gap to Skipton, and so to Leeds. From Leeds a canal continues down the Aire valley to Goole and the Humber, thus providing a water route from Liverpool to Hull.

(*e*) The Berkley Canal enables ships of small size to reach Gloucester from the Bristol Channel.

(*f*) **The Manchester Ship Canal** (36 miles long) is deep enough and wide enough for ships of considerable size to reach Salford from the Mersey.

In Scotland, the most important canal connects the estuaries of the Forth and Clyde; Grangemouth is at the eastern end, and the canal passes near the great ironworks at Falkirk. It has been proposed to make a ship canal across this part of Scotland in order to accommodate war-ships as well as merchant ships.

The Caledonian Canal connects the lochs in Glenmore (Ness, Oich, Lochy), and provides a waterway from the Moray Firth to Loch Linnhe. It is of little commercial value, but in summer many tourists pass through it.

In Ireland, canals were easily constructed to join the rivers which cross the low-lying Central Plain; the most important of these canals are:

(*a*) **Grand Canal** from Dublin to Banagher on the Shannon.
(*b*) **Royal Canal** from Dublin to the Shannon *via* Mullingar.
(*c*) **Union Canal** connecting Loughs Neagh and Erne.

(*d*) **Newry Canal** connecting Lough Neagh with Carlingford Lough.

EXERCISES.

1. State the position of Rugby, Perth, Leeds, respectively, and point out the importance of each as a railway centre.
2. The Great Western Railway connects London with Penzance, Fishguard, and Birkenhead, respectively. Briefly describe each of these routes.
3. Write a short account of the following routes: (*a*) Hull to Cork, (*b*) Bristol to Newcastle, (*c*) Carlisle to Wick.
4. Distinguish barge canals and ship canals. Give two examples of each in the British Isles.
5. Describe a route by which goods could be carried in a canal barge from Bristol to Leeds.
6. Compare the Caledonian Canal with the Manchester Ship Canal.

44. SCOTLAND.

SCOTLAND, as may be seen in Map 4, consists of three parts. They are: (1) the Highlands, (2) the Central Lowlands, (3) the Southern Uplands.

The **Highlands**, known in ancient times as Caledonia, are divided into two parts by the long, narrow, straight valley of Glen More. Along this deep valley, which contains three narrow lakes, the Caledonian Canal has been made, to allow a passage for vessels sailing from the North Sea on the east of Scotland to the Atlantic on the west. The mountains on the north are the North-West Highlands. Those on the south are the Grampian Highlands. The highest peak in Scotland and in the whole island is **Ben Nevis**, 4400 feet. The chief industry is the rearing of cattle and sheep. Scarcely any crops can be grown because of the poor soil and the wet and sunless climate. The farmers are called *crofters* and their little farms are *crofts*. In the sheltered valleys oats and potatoes are grown with difficulty.

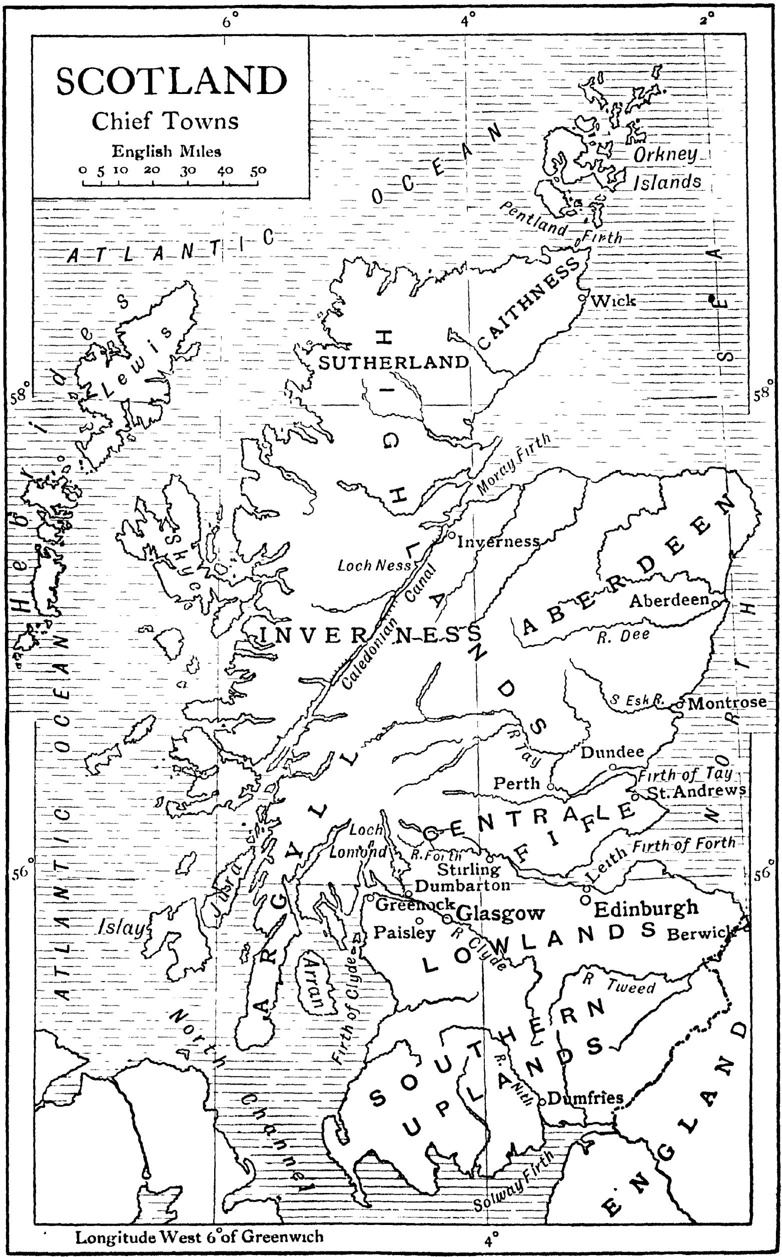
The **Central Lowlands** form the midland valley of Scotland. On these lowlands rise several groups and ranges of hills about

2000 feet high, the chief of which are the **Pentland Hills**, south-west of Edinburgh. They are volcanic, and are made of lava, poured out ages ago by volcanoes of which no trace can now be seen. In the valleys between these hills flow the rivers Tay, Forth, and Clyde. There are rich coalfields (see Fig. 110) in the Lowlands, and this has made it a great manufacturing centre. Large towns have arisen, filled with factories, the chief being Glasgow, Paisley, Greenock, and Dumbarton. These towns lie along the Clyde. The valley of the Clyde is the most important part of Scotland, for about half of the population of the whole country is settled there. The banks of the Clyde are lined with shipbuilding towns from Glasgow to Greenock and Dumbarton. Grain, especially wheat, is largely grown in the county of Fife, in the *east* of the Lowlands, and in the "Lothians," the country all round Edinburgh. Here there are broad valleys and coastal plains, and the climate is warmer than in the western counties, where dairy-farming is the chief occupation of the farmers. In the *west* there is pasture-land for cattle, especially in Ayrshire. The milk from these farms is taken to the great industrial towns.

The valleys of the rivers form gaps through the ranges of hills and lead into the Highlands to the north. In each gap there is a large town. In the Tay gap there is Perth, in the Forth gap there is Stirling, and in the Clyde gap there is Dumbarton. These towns were strong forts in former days, built to command the roads through the gaps. A railway now goes through each gap.

The **Southern Uplands** are the northern part of a hilly tract of land that stretches southward into England. It is known as the **Cheviot Hills** on the border between the two countries, and as the **Lowther Hills** in Scotland. The hills in the Southern Uplands are a little under 3000 feet in height.

In former times when Scotland had its own king, this upland tract was a strong defensive barrier between England on the south and the populous Lowlands on the north, and border warfare continued until the countries were united under the same sovereign.



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The chief rivers are the **Clyde**, the **Tweed**, and the **Nith.** The Clyde rises in the centre of the Southern Uplands. As it passes from the Uplands to the Lowlands on the north, it forms beautiful waterfalls. The most important part of the Clyde is its middle and lower course where it flows through the Lowlands.

There is no coalfield in the Southern Uplands and therefore there are no very large manufacturing towns. The plains and broad valleys on the *east*, watered by the River Tweed, are well suited for agriculture, for they are warm and sunny, compared with the hilly country in the west. In the *west* there are rich pasture-lands and sheep-rearing is the chief industry The chief manufacture, therefore, is the making of *woollen* goods (tweed cloth), but as coal has to be brought from a distance, the industry is not so important here as it is in the West Riding of Yorkshire.

CHIEF TOWNS IN SCOTLAND.

(The population in thousands is given by the figures in brackets.)

Inverness (22), on the River Ness, was once a very important town, because it guarded many routes leading to the Highlands, which crossed one another at this point. It is still considered to be the capital of the Highlands. It stands at the northern end of the Caledonian Canal. All trade must pass through it, but the trade is small because the country is thinly populated.

Aberdeen (164), a seaport on the North Sea, is by far the largest city and the chief fishing station on the north-eastern coast. It stands between the mouths of the little rivers Dee and Don, in a passage where the Highland mountains come down close to the sea, so that all traffic along the coast must pass close to it. In the town, there are factories for cutting into blocks the granite found in the hills close by. These blocks are shipped to other places. There are also shipbuilding yards, ironworks, and flax and jute manufactures. There is a famous University.

Wick (9) is the chief fishing town in the far north-eastern county of Caithness, on the coastal plain below the Highlands. The people in this part of the country are bold and skilful sailors, and fish in stormy seas on a rough and rock-bound coast. In the picture we see the huge cliffs on the coast. The stratified rock shows that they once lay at the bottom of the ocean. The waves, dashing on the shore for ages, have washed out the softer rock, and will in time wear down the rocky pillars that remain.

Glasgow (1111), the greatest manufacturing town in Scotland, is the largest city in the British Isles except London. It has a good port, and stands on the River Clyde at the nearest point to the sea where it can be bridged. It is a great railway junction, and all the traffic from the east and the west passes through it. Engines of all kinds, especially railway engines, are made here. There are enormous iron-foundries, and factories for making cotton goods, carpets, lace, and paper. There are also huge shipbuilding yards. This great town has been made what it is by its situation for trade, and by the rich coalfields and iron-mines close to it. The building of great iron ships and steamers is carried on, for 20 miles along the Clyde below Glasgow, in

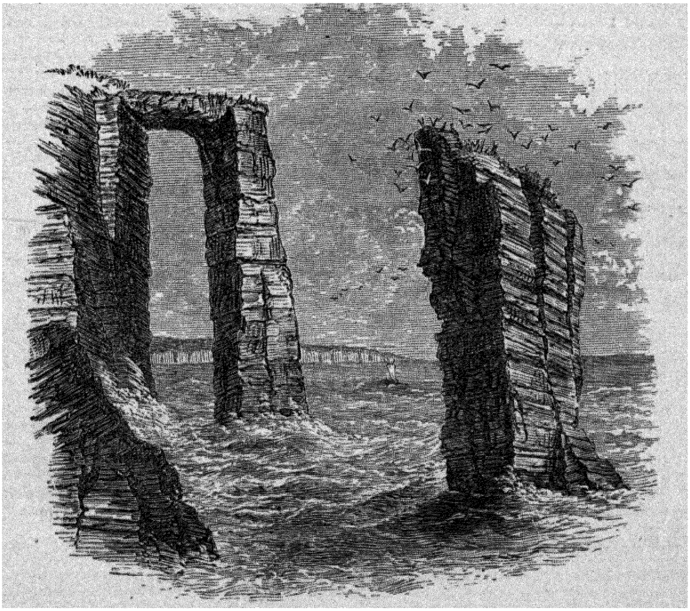


FIG. 116.—SCENE ON THE COAST OF CAITHNESS.

many towns, the chief of which are **Greenock** (79) and **Dumbarton** (22).

Paisley (89), a very large town about 7 miles from Glasgow, has very large cotton-thread mills. There are also large manufactures of machine tools. As the town is at some little distance from the iron- and coal-mines, the men of Paisley do not make large quantities of low-priced iron and steel goods, which are so heavy that they do not pay for their carriage. They manufacture costly machine tools, for which the charge for carriage is small compared with the price.

Perth (36), on the River Tay, is an ancient town famous in Scottish history, for it commands two great routes. It stands on the old road along the east coast of Scotland to Dundee and Aberdeen, and also on the route by the valley of the Tay into the heart of the Highlands. It now has large bleaching and dyeing works.

Edinburgh (333), on the Firth of Forth, about 400 miles north of London, was the capital of Scotland before the Union, and is still regarded as the capital. It is the chief town in the east of Scotland, as Glasgow is the chief town in the west. It is one of the most beautiful cities in Britain, and has been called the Modern Athens, for, like that famous city, it is built on several low hills; and on a steep rock in the centre of the town stands the citadel or castle of Edinburgh. It is a "gap town," *i.e.* it commands the gap or narrow strip of land between the Pentland Hills and the sea, so that all the traffic along the east coast must pass through it. It is a great railway centre. Edinburgh Castle, built 1200 years ago by Edwin, King of Northumbria, after whom it was named, commanded this route in ancient times. The University of Edinburgh is celebrated for its medical schools. Paper-making, printing, and publishing are flourishing trades.

Leith (83), on the Firth of Forth, is now incorporated with Edinburgh. It is sixth in size of Scottish towns, and ranks next in importance to Glasgow as a seaport. Its ships trade with the ports of Europe on the North Sea and the Baltic. In Leith, sails and ropes and everything wanted by sailors are made.

St. Andrews (8), though a small town, has the oldest University in Scotland. It is also famous for its "golf links."

Dundee (165), the third largest city in Scotland, is a seaport which stands close to the famous Tay Bridge, over which the railway runs for two miles over the arm of the sea known as the Firth of Tay. It is the chief seat of the manufacture of jute, which comes from Bengal. Out of it are made sacks and ropes. There is also a large import of flax from the Baltic seaports, which is made up into linen goods. There are many jam factories, for fruit is abundant and cheap. Shipbuilding is also an important industry.

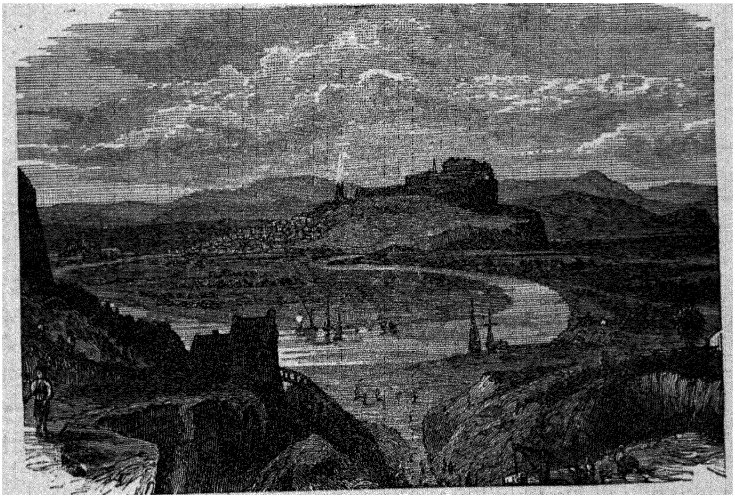


FIG. 117.—STIRLING AND RIVER FORTH.

Dunfermline, in Fifeshire, is noted for the manufacture of fine linen fabrics, and **Kirkcaldy** for linoleum.

Stirling (21), on the River Forth, is a "gap town," with an ancient castle built on a great rock or droog that rises out of the plain, and commands the route into the Highlands, by the valley of the Forth, from the Lowlands. Stirling is now an important railway junction, and has manufactures of woollen goods, chiefly blankets and carpets.

Kilmarnock, the largest town on the Ayrshire coalfield, manufactures carpets and iron and steel goods. Rolling-stock for the Glasgow and South-Western Railway is also made at this town.

EXERCISES.

1. Describe the physical features of Scotland.
2. Write an account of the rivers Clyde and Tweed. Draw a sketch map to illustrate the answer.
3. Write notes on the following Scottish industries: Woollen goods, linen manufacture, shipbuilding.
4. State position and importance of: Edinburgh, Aberdeen, Dundee, Kilmarnock, Perth, Glasgow.

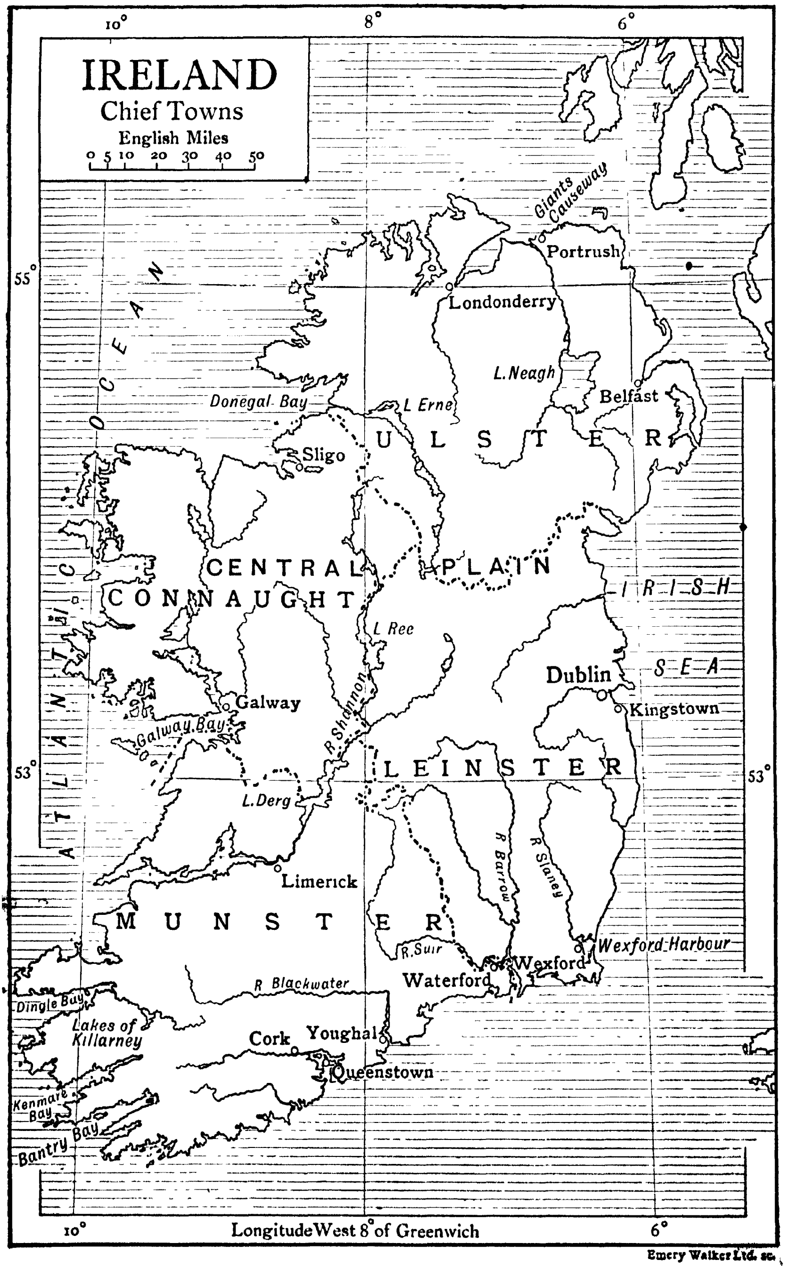
45. IRELAND.

IRELAND includes a central plain with mountains all round it. These mountains are in groups with wide gaps between them rather than in long ranges. Therefore the mountains in the north, south, east, and west of Ireland do not shut out the winds from the ocean. They blow through the gaps, right across the plain. The whole country has a maritime climate. The grass is always green, so that Ireland has been called the "Emerald Isle."

The rainfall is moderate and spread evenly all over the country, the average being about 40 inches in the year. It rises to 60 inches on the western hills. All the central plain is well-watered grass-land, some of it being marshy, with peat bogs. About one-sixth of the land is cultivated, oats and potatoes being the chief crops. Flax is grown in the north-east in the province of Ulster.

The rearing of sheep, cattle, and pigs is the chief industry of the Irish farmers. Five-sixths of the land is rich pasture, which supports large flocks of sheep and herds of cattle. Great quantities of butter, cheese, and eggs are exported to England and large numbers of cattle. There are fisheries all round the coast, chiefly in the west, and much of the fish caught is not landed in Ireland but taken straight to England.

There is scarcely any coal in Ireland, and, therefore, there are



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very few large manufacturing towns. Ireland however, is, famous for its "cottage manufactures." The women work in their cottages, especially in the north of Ireland, and knit and spin wool. They make lace from linen and cotton thread. They also make shirts and finish off shirts, made by machinery, for dealers in the market towns.

Ulster, in the north of Ireland, however, has a great manufacturing centre in Belfast, where the descendants of immigrants from England and Scotland live. Ulster is the richest, most populous, and the best cultivated part of Ireland. Linen goods are made in the factories of Belfast from flax grown in the country around, and from linen yarn imported from Belgium.

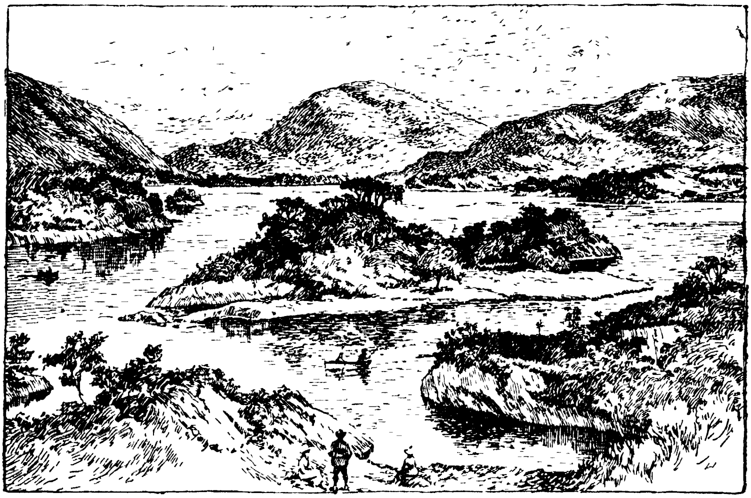


FIG. 118.—LAKES OF KILLARNEY.

The lake district of **Killarney** in the south-west of the island is the most beautiful part of Ireland. The lakes are studded with little islands well wooded, and all around there are green hills.

The south of Ireland has a very mild climate and very rich pasture land. All the seaports on the coast export live-stock, meat, and dairy produce, *i.e.* butter and cheese. Wheat and barley are cultivated in the basins of the rivers that flow into Wexford and Waterford harbours—the Suir, the Barrow, and the Slaney.

The **Shannon** is the chief river of Ireland and the longest in the British Isles. It flows slowly along the great central plain and passes through several long lakes in its course, the chief of which are Lough Ree and Lough Derg. In Ireland lakes are called *loughs*, and in Scotland they are called *lochs*. The Shannon is a beautiful stream of water. It has an estuary 70 miles long, at the head of which stands Limerick, the largest town in the south-west.

The bays in the south-west of Ireland—Dingle Bay, Kenmare Bay, and Bantry Bay—are what are known as "*Rias*." Rias were at one time river valleys, made by rivers which flowed through them. But the land sank and the sea rushed up the valleys. They are sometimes called "drowned valleys" for this reason. On the other hand, the openings of the land on the south coast are fiords like those in Norway. The ending *ford* in the names Waterford and Wexford does not refer to the ford where a river is crossed, but is another form of *fiord*. A fiord is often narrow at the entrance and opens out into the land and is often deeper there than at the entrance. A ria is wide at the entrance and gets shallower and narrower as it runs up into the land, this being the slope down which the river ran. Both rias and fiords are drowned valleys.

CHIEF TOWNS IN IRELAND.

(The population in thousands is given by the figures in brackets.)

Dublin (305), on Dublin Bay, at the mouth of the River Liffey, is the political capital of Ireland and the largest town after Belfast. It has beautiful streets, one of which is shown in the picture in Fig. 119. It was very well placed for trade. It is in the middle of a wide gap of 60 miles in the eastern mountains, so that there is an easy route into the heart of the central plain. Railways run in all directions from Dublin, north, south, and west. Dublin Bay

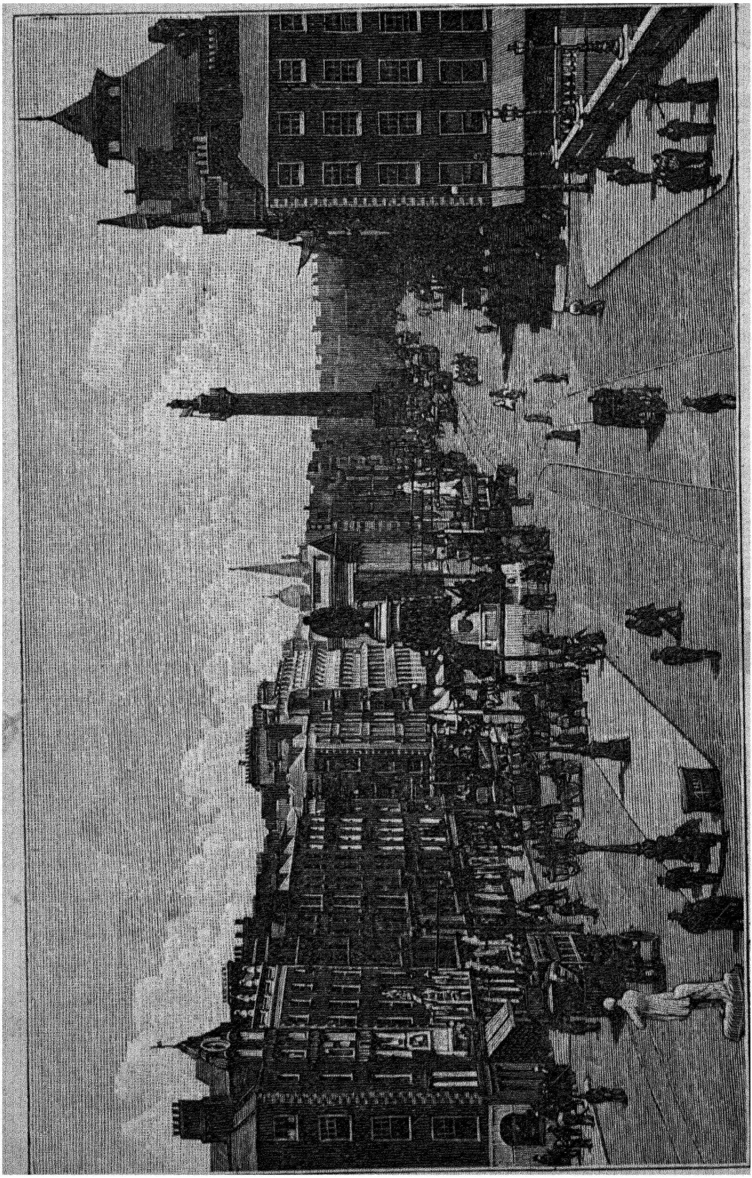


FIG. 119.—SACKVILLE STREET, DUBLIN.

is a beautiful harbour at the narrowest part of the Irish Sea; the distance from Dublin to Holyhead on the coast of Anglesea in Wales being only 60 miles. The Viceroy of Ireland lives in Dublin, where all the Government buildings are. There are several great industries in Dublin, the chief being the brewing of beer and the making of whisky. The country around is a famous grazing ground for cattle, of which large numbers are exported to England. **Kingstown**, on Dublin Bay, is an outport of Dublin. Fast mail steamers cross the Irish Sea to Holyhead.

Belfast (387), in the province of Ulster, is the largest town in Ireland and may be called the commercial capital, as Glasgow is the commercial capital of Scotland. It is well placed for trade both in England and Scotland, being on the bay called Belfast Lough. It is at the mouth of a little river, and the valley of this river opens up an easy route inland. Belfast has large manufactures, the chief industries being shipbuilding, the making and bleaching of linen goods, and the making of ropes and mineral waters. There are also large tobacco factories. In the linen industry, home-grown flax is used, as well as flax imported from Russia. Irish linen is famous for its softness and whiteness. There is scarcely any coal in Ireland, so coal and iron are imported for the factories and shipbuilding yards in Belfast from the opposite coast of Scotland. A good deal of whisky is distilled.

Londonderry (41), or Derry, is on the River Foyle, near the head of Lough Foyle. It is the fourth largest town in Ireland. The chief industry is the making of linen goods. Whisky is distilled, and there are salmon fisheries.

Sligo (11), on Sligo Bay, is the chief fishing port of the north-west of Ireland. **Galway** is noted for its fishing fleet. Although it stands on a fine harbour Galway is of little commercial importance.

Wexford (12), at the mouth of the Slaney, and **Waterford** (28), at the mouth of the Suir, are seaport towns on the south coast. They have good harbours, with rivers flowing into them. In the valleys of these rivers wheat and barley are largely grown. From these two towns the same things are exported as from Cork, viz. cattle, butter, eggs, and bacon. From **Rosslare**, near Wexford, steamers cross the St. George's Channel to Fishguard.

Limerick (39), at the mouth of the Shannon, the great river of Ireland, is the only town of any size in western Ireland. It is the chief market-town of the west. To it the farmers bring for sale their cattle and crops. In the town there are flour-mills, and the largest bacon-curing factories in Ireland. Hides are made into leather. To the south of Limerick is one of the most fertile districts in Ireland, known as the Golden Vale.

Cork (77), at the mouth of the River Lee, is the third largest town in Ireland, and may be called the capital of the south. It has a fine harbour, which is strongly fortified, and is a naval station and dockyard. Cork exports more butter, eggs, and bacon than any other town in the British Isles.

Queenstown, on an island in Cork Harbour, is a calling place for liners on their way from Liverpool to New York.

EXERCISES.

1. Write an account of the central plain.
2. Why is Ireland noted for dairy-farming? From what ports is dairy produce exported and where does it go?
3. State the position of Belfast and describe its industries.
4. Write notes on: Killarney, Giant's Causeway, Lough Neagh.

46. SPAIN, PORTUGAL, AND FRANCE.

(In the following lessons, the population of a town *in thousands* is given by the figures in brackets.)

SPAIN and Portugal together make up the Iberian Peninsula, a huge plateau, which is crossed by high ranges of hills, called Sierras (Saws) from the jagged edges of their long summit lines. On the plateau the climate is extreme, with cold winters, hot summers, and a scanty rainfall of less than 20 inches in the year.

The plateau slopes from east to west, and five of the six large rivers marked on the map flow in this direction, through deep narrow valleys, between the Sierras, into the Atlantic Ocean. They are (from north to south) the **Minho**, the **Douro**, the **Tagus** (566 miles), the **Guadiana**, and the **Guadalquivir.** These rivers flow so rapidly and are so shallow that all but the last are nearly useless for navigation or even for irrigation. The Guadalquivir (374 miles), however, is navigable from Seville to the ocean. The sixth river, the **Ebro** (470 miles), flows through the north-east of Spain into the Mediterranean, across fertile plains, which it irrigates.

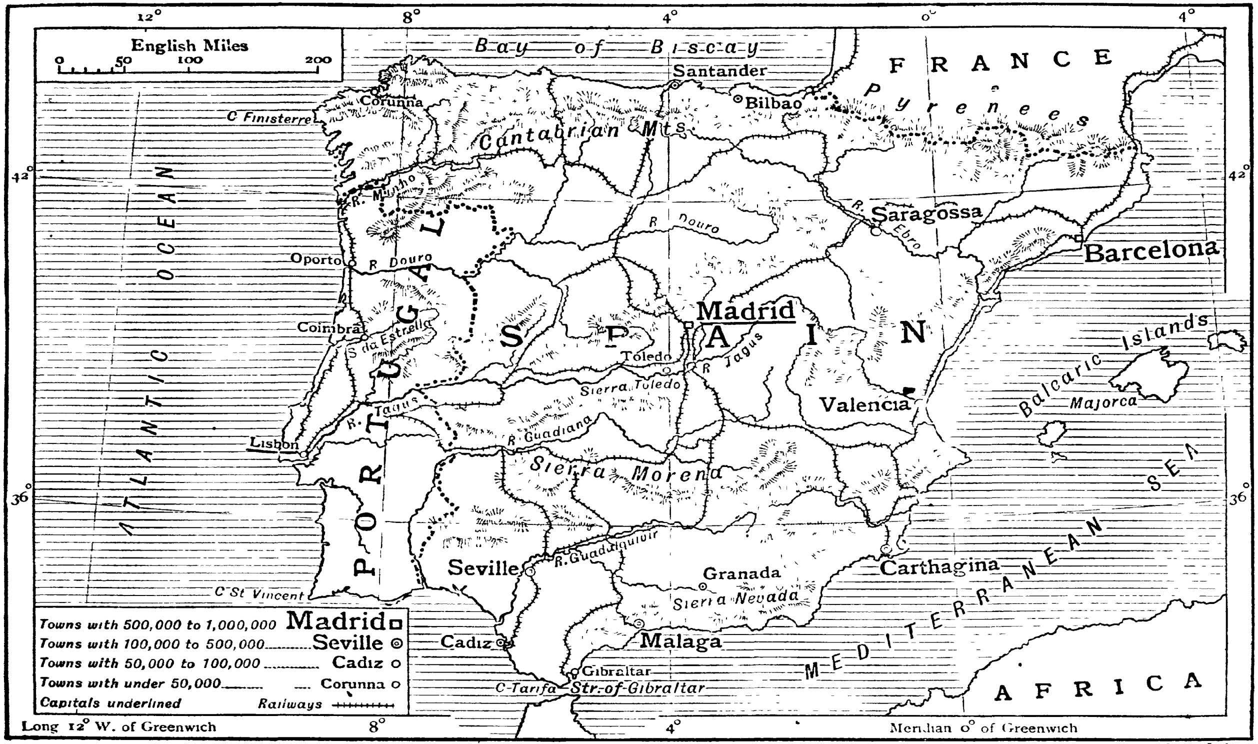
The **Pyrenees** divide Spain from France. They are a lofty range of folded mountains rising to 11,000 feet, and are continued in the **Cantabrian** Mountains along the Atlantic coast. The **Sierra Nevada**, in the south, rises still higher along the Mediterranean coast to 11,700 feet. The Sierras of the plateau are the **Sierra da Estrella** (in Portugal), **Sierra Guadarama, Sierra Toledo**, and **Sierra Morena.**

The eastern Mediterranean region produces in abundance oranges, olives, nuts, raisins, sugar, rice, cotton, and tobacco. On the western slopes of the hills facing the Atlantic grow fine grapes from which wine is made. On the plateau "esparto grass" is grown for paper-making.

Minerals abound in the mountains of Spain. Iron of very good quality is found around Bilbao in the north, and is largely exported to Britain. The copper mines of Rio Tinto in the Sierra Morena are the largest in the world. There are great coalfields in the north, in the Cantabrian Mountains, and famous quicksilver mines on the northern slopes of the Sierra Morena. Silver, lead, and zinc are also mined.

SPAIN.—The *population* of Spain (in 1913) was a little over 20 millions. The industries of the country are *mining*, where metals are found, especially in the north, where there is a large supply of coal and iron; *fishing* along the sea-coast; the *grazing* of sheep (which give the well-known Merino wool) on the hills, *farming* (wheat, barley, oats, rye, maize, and millets) and *fruit-growing* in the Mediterranean region; and *manufactures* of cotton and silk goods, of paper, and leather in many of the large towns, *e.g.* Barcelona.

SPAIN & PORTUGAL



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Madrid (600), the capital, is a nodal town, being the centre of the railway system. **Barcelona** (587), the chief seaport, on the Mediterranean, is the largest manufacturing town in Spain, and the outlet for the produce of the fertile valley of the Ebro. **Valencia** (233), on the east coast, is a seaport with much trade in wine and fruit. It is the chief seat of the silk industry. **Seville** (158), on the Guadalquivir, is the second port in Spain. Seville oranges are well known everywhere. **Malaga** (137) is a large seaport on the south coast, with great trade in fruit and wine. **Carthagena** (103), on the south-east coast, is the chief naval port of Spain. **Cadiz** (67) is a strongly fortified naval harbour. **Granada** (81), in the basin of the Guadalquivir, an ancient town famous for the Alhambra, a splendid building erected by the Moors when they ruled the country. **Saragossa** (112) is a large river port on the Ebro, and the largest town in the basin of that river. It has a splendid cathedral, to which pilgrims come from every part of Spain. **Gibraltar** (18), which belongs to the British, is the key to the Mediterranean Sea. It is built on a very strongly fortified rocky hill, about 1400 feet high, which runs about three miles out into the sea. It is known as "the Rock." The opposite coast of Africa may be clearly seen across the straits. It has a splendid harbour, in which a large fleet can anchor, and is one of the chief coaling stations of the British Navy.

PORTUGAL.—The republic of Portugal includes the coastal plain watered by the Minho, the Douro, the Tagus, and the western slopes and crests of the plateau up to a height of 7000 feet. The Sierra da Estrella divides northern from southern Portugal. About six-sevenths of the population live in the northern part.

The most important products are wine and cork. Cattle are reared on the hills, and wheat, rye, and maize are grown in the fields. Olives, figs, and tomatoes are also cultivated.

The *population* of Portugal was about 6 millions in 1911.

Lisbon (435), on a wide estuary of the Tagus, has one of the best natural harbours of the world. All the trade and commerce of the country pass through it. The chief export is wine. **Oporto** (194) is at the mouth of the Douro, which waters a fertile valley in which grapes grow abundantly. It is the second town and port of Portugal for the export of wine. **Coimbra**, midway between Oporto and Lisbon, has the only University in Portugal. It has the heaviest rainfall in Europe.

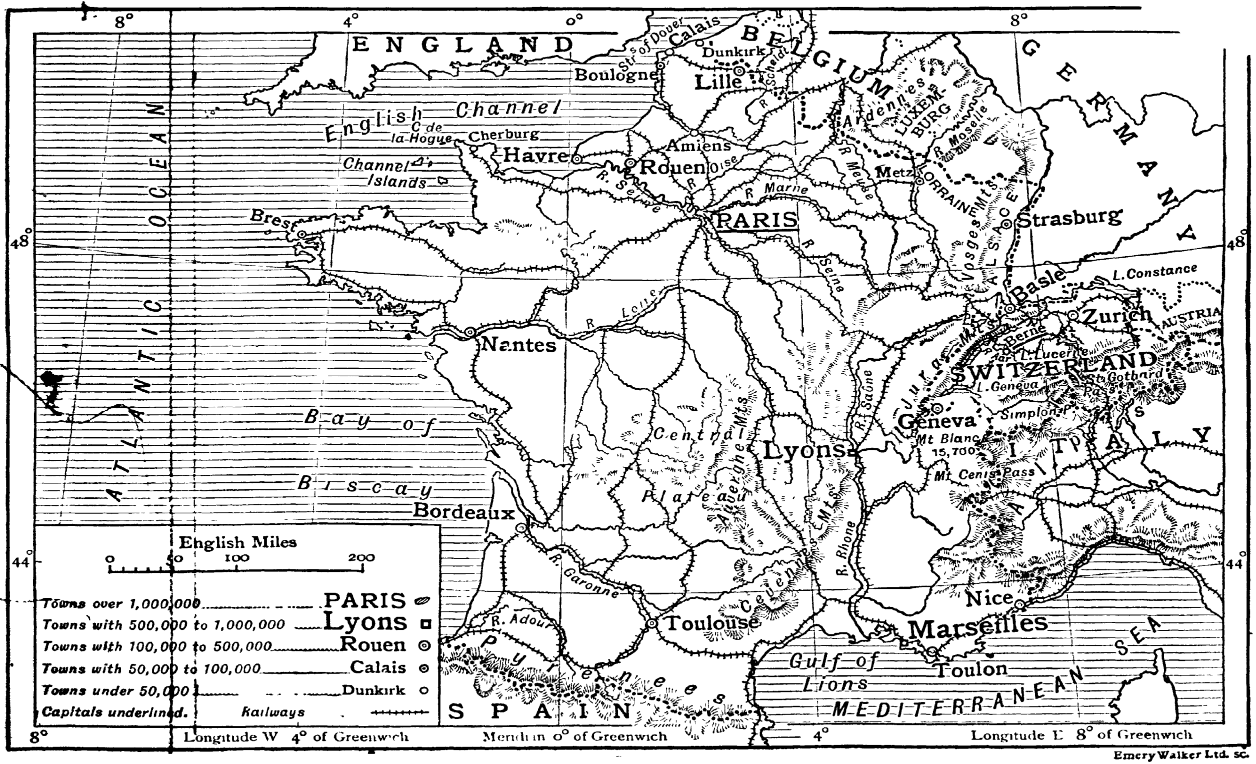
FRANCE is naturally divided into two regions. All the north and west of the country is a fertile well-watered plain, lying open to the warm westerly breezes from the Atlantic. The centre, the south, and the east are made up of plateaus, hills, and mountains. On the central plateau rise the mountains of Auvergne to a height of 6000 feet, and to the south-east the Cevennes (5600 feet). The deep valley of the Rhone separates the plateau from the Alps, the western slopes of which, including Mont Blanc (15,800 feet), are in France. North of the Rhone valley rise the **Jura** Mountains (5000 feet) and the **Vosges** Mountains (4000 feet). On the south the Pyrenees (6000 to 10,000 feet) divide France from Spain.

The four largest rivers of France are the Loire (540 miles), the Rhone (504), the Seine (480), and the Garonne (535). At the mouth of each of these rivers there is a large seaport town, which is the gate through which exports and imports pass.

The climate of the greater part of France is pleasant. The north and west are warmed by the breezes from the Atlantic, the southern part by breezes from the Mediterranean. The mean annual rainfall is about 30 inches.

The south-eastern corner is very fertile, and has been called the Garden of France. Here the orange, the olive, and the mulberry flourish. On the mulberry leaf silk-worms feed. Silk is one of the chief exports of France. The principal crop of the country is *wheat*; France grows more wheat than any other country in Europe. The crops in order of value are: potatoes, wheat, oats, beetroot, rye, and barley. The *Vine* grows very well in the river basins and on the slopes of the hills. The wines of France, both red and white, are more largely drunk than those of any other country. Fruit-trees grow everywhere,

FRANCE & SWITZERLAND



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e.g. the apple, the pear, the peach, and the plum. Flax is largely cultivated in the north-eastern plain.

Industries.—In north-eastern France *Woollen* and *Cotton Goods* are manufactured, for the ports on the Atlantic are well placed for the import of cotton and wool from abroad, and sheep thrive on the northern plains. Lille is a great centre of textile industries, especially linen and cotton goods; Roubaix for *woollens*, Valenciennes, *lace*, Cambrai, *linen*, Rouen, *cotton*. *Silk* is made in the valley of the Rhone. *Iron* and *Steel Goods* are made in the north-east, where there are coalfields. *Wine* is made in many parts of France, the chief districts being Champagne, Burgundy, Bordeaux. Watches, jewels, ribbons, lace, gloves, hats, and articles of dress are made in Paris. *Fishing* employs many men on the coast of Brittany. From these fishermen sailors for the French merchant ships and navy are taken. The sardine fishery in the Bay of Biscay is now less important than formerly.

The *population* in 1911 was 39,600,000. There are fourteen towns with over 100,000 inhabitants, and twenty-four more with from 50,000 to 100,000.

Paris (2888), the capital, on the Seine, is the second city in Europe in size and the most beautiful. The map shows that it is a great nodal town. Railways run to it from all parts of France. **Marseilles** (551), at the mouth of the Rhone, is on the Gulf of Lyons. It has a splendid harbour and is the first port in France. It has enormous trade and large manufactures, the chief of which are soap and oil. All the exports and imports of the valley of the Rhone pass through it. **Lyons** (524), at the junction of the Rhone and its chief tributary the Saone, has the largest silk manufactures in the world. **Bordeaux** (262), at the mouth of the River Garonne, has great trade in wine (Claret), being the centre of a land of grapes. **Lille** (218), in the centre of the north-east coal-field, is a large town with manufactures of iron and steel goods, rails, engines, and glass; also flax and hemp. It is on the frontier of Belgium and is strongly fortified. **Toulouse** (150), in the south, on the River Garonne, has much trade with